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[54] **SILICA REINFORCED RUBBER COMPOSITION AND USE IN TIRES**

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[58] **Field of Search** 524/492, 493, 524/495, 496, 430, 444, 445, 447

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,978,103	8/1976	Meyer-Simon et al.	260/448.8 R
4,076,550	2/1978	Thurn et al.	106/288 Q
4,433,114	2/1984	Coran et al.	525/332.6

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[57] **ABSTRACT**

The invention relates to a process for preparation of a rubber composition containing silica reinforcement through the utilization of a high purity organosilane disulfide.

Pneumatic tires having treads prepared by such process are provided.

76 Claims, No Drawings

SILICA REINFORCED RUBBER COMPOSITION AND USE IN TIRES

FIELD

This invention relates to the preparation of rubber compositions which contain silica reinforcement and utilizing a silica coupler, or adhesive agent, in a form of a relatively high purity organosilane disulfide.

The invention also relates to the preparation of tires having treads thereof. In one aspect, the rubber composition is comprised of a sulfur curable rubber reinforced with a combination of silica, alumina and/or aluminosilicate, optionally carbon black, and a silica coupler, or adhesive agent, in a form of a relatively high purity organosilane disulfide.

BACKGROUND

For various applications utilizing rubber which require high strength and abrasion resistance, particularly applications such as tires and various industrial products, sulfur cured rubber is utilized which contains substantial amounts of reinforcing fillers. Carbon black is commonly used for such purpose and normally provides or enhances good physical properties for the sulfur cured rubber. Particulate, precipitated silica is also sometimes used for such purpose, particularly when the silica is used in conjunction with a coupling agent. In some cases, a combination of silica and carbon black is utilized for reinforcing fillers for various rubber products, including treads for tires.

In some cases alumina has been used for such purpose either alone or in combination with silica. The term "alumina" can be described herein as aluminum oxide, or Al_2O_3. Use of alumina in rubber compositions, can be shown, for example, in U.S. Pat. No. 5,116,886 and European Patent publication EPO 631,982 A2.

It is recognized that alumina can be in various forms, namely, acidic, neutral and basic forms. Generally, it is considered herein that the neutral form may be preferred.

In some cases aluminosilicates might be used for such purpose. The term "aluminosilicates" can be described as natural or synthetic materials where the silicon atoms of a silicon dioxide are partially replaced, or substituted, either naturally or synthetically, by aluminum atoms. For example, about 5 to about 90, alternatively about 10 to about 80 percent of silicon atoms of a silicon dioxide might be replaced, or substituted, naturally or synthetically, by aluminum atoms to yield an aluminosilicate. A suitable process for such preparation might be described, for example, as by a coprecipitation by pH adjustment of a basic solution, or mixture, of silicate and aluminate also, for example, by a chemical reaction between SiO_2, or silanols on the surface of a silicon dioxide, and $NaAlO_2$. For example, in such coprecipitation process, the synthetic coprecipitated aluminosilicate may have about 5 to about 95 of its surface composed of silica moieties and, correspondingly, about 95 to about 5 percent of its surface composed of aluminum moieties.

Examples of natural aluminosilicates are, for example, Muscovite, Beryl, Dichroite, Sepiolite and Kaolinire. Examples of synthetic aluminosilicates are, for example, Zeolite and those which might be represented by formulas such as, for example, $[(Al_2O_3)_x.(SiO_2)_y.(H_2O)_z]$; $[(Al_2O_3)_x.(SiO_2)_y.MO]$; where M is magnesium or calcium. Use of aluminosilicates in rubber compositions, can be shown, for example, in U.S. Pat. No. 5,116,886, European Patent publication EPO 063,982 A2, *Rubber Chem. Tech.*, Volume 50, page 606 (1988) and Volume 60, page 84 (1983).

It is important to appreciate that, conventionally, carbon black is a considerably more effective reinforcing filler for rubber products, and particularly for rubber tire treads than silica unless the silica is used in conjunction with a coupling agent, which may sometimes be referred to as a silica coupler or silica adhesive compound or coupling agent.

Such silica coupler or silica adhesive agent may, for example, be premixed, or pre-reacted, with the silica particles or added to the rubber mix during the rubber/silica processing, or mixing, stage. If the coupling agent and silica are added separately to the rubber mix during the rubber/silica mixing, or processing stage, it is considered that the coupling agent then combines in situ with the silica.

In particular, such coupling agents are sometimes composed of an organosilane such as an organosilane polysulfide which has a constituent component, or moiety, (the silane portion) capable of reacting with the silica surface and, also, a constituent component, or moiety, capable of reacting with the rubber, particularly a sulfur vulcanizable rubber which contains carbon-to-carbon double bonds, or unsaturation. In this manner, then, the coupler acts as a connecting bridge between the silica and the rubber and thereby enhances the rubber reinforcement aspect of the silica.

Numerous coupling agents are taught for use in combining silica and rubber, such as, for example, silane coupling agents containing a polysulfide component, or structure in which the polysulfide bridge portion may be composed of from 2 to 8 sulfur units, such as, for example, an organosilane polysulfide sometimes referred to as bis-(3-triethoxysilylpropyl)tetrasulfide, available from Degussa GmbH, for example, as Si69. It is understood that the sulfur bridge portions of such "tetrasulfide", while having an average of about 3.5 to about 4 connecting sulfur atoms, actually has from about 2 to about 6 or 8 connecting sulfur atoms in its bridge portions where not more than 25 percent of its bridge portions contain two connecting sulfur atoms. Therefore, it is considered herein that at least 75 percent of its sulfur bridge portions contain 3 or more connecting sulfur atoms. For example, see U.S. Pat. Nos 4,076,550; 4,704,414; and 3,873,489.

It is recognized that such organosilane polysulfides which contain 3 or more connecting sulfur atoms in their sulfur bridges can also act as a sulfur donor for the liberation of free sulfur to participate in a vulcanization, or partial vulcanization, of a sulfur vulcanizable elastomer since free sulfur may be liberated therefrom at a temperature of, for example, about 150° C. above. It is considered herein that such recited temperature is approximate in nature and is dependent upon a choice of various individual organosilane polysulfides as well as other factors, although it is believed that at temperatures lower than about 150° C., for most practical organosilane polysulfides which contain from 3 to 8 sulfur atoms in their sulfur bridge portions, the liberation of free sulfur, if any, occurs at a relatively slow rate.

Such temperatures may be experienced, for example, in preparatory, or what is often called non-productive, mixing step for blending rubber and rubber compounding ingredients, typically exclusive of addition of free sulfur, sulfur donors and/or rubber vulcanization accelerators. Such mixing might typically occur, for example, at a temperature in a range of up to about 140° C. to about 180° C.; and most likely at least a portion of the mixing occurs at a temperature of at least 160° C. or above. The small amount of free,

liberated, sulfur is then available to combine with and/or possibly partially vulcanize, the unsaturated elastomer with which the silica and coupler are being mixed in such mixing stages.

Bis-(3-triethoxysilylpropyl) disulfide, as a variety of organosilane polysulfide, is also taught as being useful as a silica coupler for a silica-containing sulfur vulcanizable elastomer composition, even as a high purity form of such disulfide in, for example, U.S. Pat. No. 4,046,550 and German Patent Publication DT 2,360,471. However, it is considered herein that such disulfide does not ordinarily liberate free sulfur in such aforementioned rubber/silica/coupler mixing operation.

In practice, sulfur vulcanized elastomer products are typically prepared by thermomechanically mixing rubber and various ingredients in a sequentially stepwise manner followed by shaping and curing the compounded rubber to form a vulcanized product.

First, for the aforesaid mixing of the rubber and various ingredients, typically exclusive of sulfur and sulfur vulcanization accelerators, the elastomer(s) and various rubber compounding ingredients are typically blended in at least one, and usually at least two, preparatory thermomechanical mixing stage(s) in suitable mixers. Such preparatory mixing is often referred to as non-productive mixing, or non-productive mixing steps or stages. Such preparatory mixing is usually conducted at temperatures up to about 140° C. to 190° C. and often up to about 150° C. to 180° C.

Subsequent to such preparatory mix stages, in a final mixing stage, sometimes referred to as a productive mix stage, sulfur and sulfur vulcanization accelerators, and possibly one or more additional ingredients, are mixed with the rubber compound, or composition, typically at a temperature in a range of about 100° C. to about 130° C., which is a lower temperature than the temperatures utilized in the preparatory mix stages in order to prevent or retard premature curing of the sulfur curable rubber, which is sometimes referred to as scorching, of the rubber composition.

The rubber mixture, sometimes referred to as a rubber compound or composition, is typically allowed to cool, sometimes after or during a process of intermediate mill mixing, between the aforesaid various mixing steps, for example, to a temperature of about 50° C. or lower.

Such sequential non-productive mixing steps, including the intermediary mill mixing steps and the concluding final mixing step are well known to those in the rubber mixing art.

By thermomechanical mixing, it is meant that the rubber compound, or composition of rubber and rubber compounding ingredients, is mixed in a rubber mixture under high shear conditions where it autogeneously heats up, with an accompanying temperature rise, as a result of the mixing primarily due to shear and associated friction within the rubber mixture in the rubber mixer.

Such thermomechanical rubber compound mixing procedure and associated sheer and accompanying temperature rise aspects are well known to those having experience in the rubber preparation and mixing art.

Where an organosilane polysulfide, or organosilicon polysulfide as it might sometimes be referred to, is used as a silica coupler in a silica reinforced, sulfur curable rubber composition, it is typically added in one or more of such preparatory, non-productive, mix stages where, as hereinbefore pointed out, the mixing may typically occur at a temperature up to, for example, about 140° C. to about 190° C. or perhaps up to about 150° C. to about 180° C.

Uniquely, when such hereinbefore described organosilane polysulfide containing three or more connecting, or connected-in-series, bridge sulfur units is utilized and added in an aforesaid preparatory mix stage in which sulfur vulcanizable elastomers, silica and associated compounding ingredients are mixed to a temperature to, for example, about 140° C. to about 180° C., at least three chemical reactions are considered herein to take place.

The first reaction is a relatively fast reaction and is considered herein to take place between the silica and the silane moiety of an organosilane, such as, for example, an organosilane polysulfide. Such reaction may occur at a relatively low temperature such as, for example, at about 120° C. Such reaction is well known to those having experience in the silica reinforcement of sulfur vulcanizable elastomers in which organosilane polysulfides are used as silica coupling agents.

The second and third reactions are considered herein to take place between the polysulfidic part of the organosilane polysulfide, or silica coupling agent, and the sulfur vulcanizable elastomer, which contains carbon-to-carbon double bonds, at a higher temperature; for example, above about 140° C. One or more of such second and third reactions are believed to be well known to those having skill or experience in such art.

The aforesaid second reaction is considered herein to consist in a degree of grafting of the organosilane polysulfide onto the elastomer backbone through a covalent bond between a sulfur of the organosilane polysulfide and a carbon atom of the polymer chain of the elastomer, probably a carbon atom alpha to a carbon-to-carbon double bond in the elastomer. Such a mechanism has been described in the literature (S. Wolff, *Rubber Chem. Tech.*, 55 (1982) 967). This reaction is believed herein to be a key for the reinforcing action of organo silane polysulfide coupling agent in silica reinforced sulfur vulcanizable, or sulfur vulcanized as the case may be, rubber compositions.

The third reaction is considered herein as being dependent upon the organosilane polysulfide as a sulfur donor, or a provider of free sulfur. Because of the nature of the thermal stability of the S_x (where x is 3 or more) bridge of the organosilane polysulfide, the energy and associated resultant temperature, particularly a temperature in a range of about 150° C. to about 180° C., involved in thermomechanical mixing of rubber compositions is sufficient to break the sulfur bridge of organosilanes polysulfides a with a sulfur bridge of three or more connecting sulfur atoms. Thus, a small amount of free sulfur is usually formed. Such small amount of liberated free sulfur is then available to partially vulcanize the elastomer in a normal elastomer vulcanization manner. Such partial vulcanizing, or curing, can be considered as somewhat of a side reaction in a sense that such vulcanization is not considered herein as a direct aspect of coupling the silica to the rubber via the silica coupler, or adhesive agent. Indeed, such pre- or partial vulcanization, or partial crosslinking, of the elastomer by the liberated free sulfur can lead to significant processing difficulties where the resultant viscosity of the rubber composition becomes too high to be suitably processed in typical rubber mixing and/or processing equipment or, in an alternative, the resultant viscosity of the rubber composition may becomes somewhat inconsistent from rubber batch to rubber batch, particularly where the rubber composition mixing time or temperature may incrementally vary.

Accordingly, and in part because of the complexity of the combination of both the aforesaid desirable silane-polymer chemical reaction and, also, the sulfur donor effect of the organosilane polysulfide containing a bridge of three or

more connecting sulfur atoms, occurring within the aforesaid rubber composition mixing processes at temperatures in a range of about 140° C. to about 180° C. under high sheer conditions, it has been observed that it is sometimes difficult to obtain a consistent rubber product, from rubber mixture to rubber mixture, as may be evidenced by rubber products with inconsistent physical properties. Accordingly, the complexity of the possible reaction mechanisms makes it very difficult, if not impractical in some cases, to suitably control the overall reaction of the organosilane polysulfide reaction and the processing of the rubber, particularly during the non-productive mixing steps while the aforesaid multiplicity of chemical reactions are taking place.

It is proposed, and as hereinafter set forth has been discovered, that a very different and more controllable sulfur/rubber interaction can be effected where the aforesaid covalent bonding between the silane coupling agent and the elastomer (aforesaid second reaction) on the one hand and the aforesaid sulfur donor effect (aforesaid third reaction) on the other hand are decoupled from each other, at least insofar as the organosilane polysulfide is concerned.

Indeed, such decoupling is considered herein to be an important and significant aspect of the invention.

In order to accomplish the decoupling effect, it is envisioned to limit the organosilane polysulfide to an organosilane polysulfide in which the polysulfide is limited to a disulfide, or at least a relatively high purity disulfide. Such high purity organosilane disulfide would contain minimal, if any, attendant, or accompanying, organosilane polysulfides containing a sulfur bridge of three or more connecting sulfur atoms.

The action of the organosilane disulfide might be explained, for example, in the following way:

First, the disulfide moiety of the organosilane disulfide does not appreciably or readily form free sulfur during the aforesaid preparatory, nonproductive rubber mixing steps at temperatures in a range of 140° C. to 180° C., particularly during the relatively short individual mixing periods in a typical rubber mixing step, or sequential series of, as the case may be, mixing steps, in a rubber mixer or mixers of an overall mixing period, of, for example, less than about 15 minutes or perhaps even 20 or more minutes. This is because, for the organosilane polysulfide, the energy required to break the sulfur-to-sulfur bonds of the disulfidic bridge and/or the associated carbon-to-sulfur bonds adjacent to the disulfidic bridge is much higher than the energy needed to similarly break such bonds for a polysulfidic bridge composed of three or more connecting sulfur atoms in an otherwise similar organosilane polysulfide.

Therefore, it has occurred to the inventors that, in a process of mixing sulfur curable rubber, silica and organosilane polysulfide at elevated temperatures, the reaction involving the formation of a covalent bond between the organosilane polysulfide and the elastomer (aforesaid second reaction) can be decoupled from a sulfur donating effect (aforesaid third reaction) may be accomplished by using such organosilane polysulfide in a form of a relatively high purity disulfide version of the polysulfide in combination with a separate and independent addition of a vulcanization accelerator, or a sulfur source such as, for example, a source of free, or elemental, sulfur, or a combination of both vulcanization accelerator and sulfur source during at least one of the aforesaid preparatory rubber composition mixing steps.

Such sulfur source may be, for example, in a form of elemental sulfur, or S_8, itself, or a sulfur donor. A sulfur donor is considered herein as a sulfur containing organic compound which liberates free, or elemental sulfur, at a temperature in a range of about 140° C. to about 190° C. Such sulfur donors may be, for example, although are not limited to, polysulfide vulcanization accelerators and organosilane polysulfides with at least three connecting sulfur atoms in its polysulfide bridge.

The amount of free sulfur source addition to the mixture can be controlled or manipulated as a matter of choice relatively independently from the addition of the aforesaid organosilane disulfide. Thus, for example, the independent addition of sulfur source may be manipulated by the amount of addition thereof and by sequence of addition relative to addition of other ingredients to the rubber mixture such as, for example, the silica reinforcement.

In such manner, then, the organosilane disulfide, with its two connecting sulfur atoms in its sulfur bridge portion, could be utilized for the aforesaid first and second associated reactions and the independent addition of the sulfur source particularly a free sulfur source, could be primarily relied upon for the aforesaid third reaction.

Thus, it is considered herein, that at least a partial decoupling of the aforesaid reactions is postulated.

It is considered herein that such manipulation of the sulfur/rubber interaction, combined with the aforesaid silane/silica interaction in a preparatory rubber mixing step is a significant departure from known prior practice.

It is recognized that prior patent publications recite, or include, the use of organosilane disulfides as silica couplers in elastomer formulations. For example, see U.S. Pat. No. 4,076,550 and German Patent Publication DT 2,360,470 A1. However, it is believed that the inventors' prescribed procedure of utilizing a relatively high purity organosilane disulfide in combination with independently adding a free sulfur source in a preparatory rubber-silica mixing step, particularly as a means of controlling the associated sulfur/elastomer interaction is an inventive departure from prior practice. Such procedure has been observed to provide a better reproducability of rubber compound physical properties as well as considerably greater compounding, or mixing, flexibility as indicated by the controllable reaction effect.

Further to the aforesaid inventive concept, it is also considered herein that an addition of an alkyl silane to the coupling agent system (organosilane disulfide plus additional free sulfur source and/or vulcanization accelerator) typically in a mole ratio of alkyl silane to organosilane disulfide in a range of about 1/50 to about ½ promotes an even better control of rubber composition, or compound, processing, and usually resultant compound aging under aging conditions such as exposure to moisture and/or ozone.

The term "phr" as used herein, and according to conventional practice, refers to "parts of a respective material per 100 parts by weight of rubber, or elastomer".

In the description of this invention, the terms "rubber" and "elastomer" if used herein, may be used interchangeably, unless otherwise prescribed. The terms such as "rubber composition", "compounded rubber" and "rubber compound", if used herein, are used interchangeably to refer to rubber which has been blended or mixed with various ingredients and materials and "rubber compounding" or "compounding" may be used to refer to the mixing of such materials. Such terms are well known to those having skill in the rubber mixing or rubber compounding art.

A reference to an elastomer's Tg, if used herein, refers to a glass transition temperature which can be determined by a differential scanning calorimeter at a heating rate of 10° C. per minute.

SUMMARY AND PRACTICE OF THE INVENTION

In accordance with one aspcct of this invention, a rubber composition is prepared by a process which comprises the sequential steps of:

(A) thermomechanically mixing in at least one preparatory mixing step to a temperature of about 140° C. to about 190° C., alternatively to about 150° C. to about 185° C., for a total mixing time of about 2 to about 20, alternatively about 4 to about 15, minutes for such mixing step(s) (i) 100 parts by weight of at least one sulfur vulcanizable elastomer selected from conjugated diene homopolymers and copolymers and copolymers of at least one conjugated diene and aromatic vinyl compound, (ii) about 15 to about 100, alternatively about 30 to about 90, phr of particulate filler comprised of at least one of precipitated silica, alumina, aluminosilicate and carbon black, wherein said filler contains about 5 to about 85 weight percent carbon black, (iii) about 0.05 to about 20 parts by weight per part by weight of said particulate filler of at least one organosilane polysulfide compound having the formula:

$$Z—R^1—S_n—R^1—Z$$

wherein n is an integer of from 2 to 8 provided, however, that at least 80 percent, and preferably about 95 to about 100 percent, of n is 2;

wherein Z is selected from the group consisting of:

$$\begin{array}{c} R^2 \\ | \\ —Si—R^2 \\ | \\ R^3 \end{array} \quad \begin{array}{c} R^2 \\ | \\ —Si—R^3 \\ | \\ R^3 \end{array} \quad \text{and} \quad \begin{array}{c} R^3 \\ | \\ —Si—R^3 \\ | \\ R^3 \end{array}$$

wherein R^2 may be the same or different and is individually selected from the group consisting of alkyl group having 1 to 4 carbons and phenyl; R^3 may be the same or different and is individually selected from the group consisting of alkyl groups having 1 to 4 carbon atoms, phenyl, alkoxy groups having 1 to 8 carbon atoms and cycloalkoxy groups with 5 to 8 carbon atoms; and R^1 is selected from the group consisting of a substituted or unsubstituted alkylene group having a total of 1 to 18 carbon atoms and a substituted or unsubstituted arylene group having a total of 6 to 12 carbon atoms;

(iv) at least one additional additive as a compound selected from (a) a free sulfur source selected from at least one of (1) elemental sulfur and (2) at least one sulfur donor as a polysulfidic organic compound containing sulfur and having a property of releasing at least a portion of said sulfur at a temperature in a range of about 140° C. to about 190° C.; provided, however, that the total of said free sulfur from said elemental sulfur addition and available from said sulfur donor addition is in a range of about 0.05 to about 2 phr, alternatively about 0.2 to about 1 phr, and (b) about 0.1 to about 0.5, alternatively about 0.1 to about 0.3, phr of at least one vulcanization accelerator for sulfur vulcanizable elastomers that is not such a sulfur donor;

(B) subsequently blending therewith, in a final thermomechanical mixing step at a temperature to about 100° C. to about 130° C. for a time of about 1 to about 3 minutes, about 0.4 to about 3 phr of elemental sulfur provided, however, that the total elemental sulfur and sulfur available from said sulfur donor addition introduced in said preparatory mixing steps and elemental sulfur added in said final mixing step is in a range of about 0.45 to about 5 phr, and at least one sulfur vulcanization accelerator.

In one aspect of the invention such process is provided wherein said preparatory mixing is conducted in at least two thermomechanical mixing steps, of which at least two of such mixing steps are to a temperature in a range of about 140° C. to about 190° C., with intermediate cooling of the rubber composition between at least two of said mixing steps to a temperature below about 50° C.

In further accordance with this invention, a rubber composition is prepared wherein preparatory steps (A) are composed of at least two sequential mixing steps in which said elastomer, said particulate filler and said organosilane polysulfide compound, in which at least 80 percent of n is 2 or alternatively in which at least 95 percent of n is 2, are mixed in onc or more sequential mixing steps and in which said sulfur source and/or vulcanization accelerator is/are added in a subsequent sequential preparatory mixing step.

In additional accordance with this invention, a rubber composition is prepared wherein said preparatory steps (A) are composed of at least two sequential mixing steps in which about 20 to about 60 weight percent of the silica, the said organosilane disulfide compound and said sulfur source and/or vulcanization accelerator are added in the first mix step and the remainder thereof added in at least one subsequent preparatory mix step.

In accordance with the process of this invention, the said high purity organosilane disulfide, namely, the said organosilane polysulfide compound where at least 80 percent and, alternatively, at least 95 percent of n is 2, is optionally added to the thermomechanical preparatory mixing in a form of a particulate comprised of (a) about 25 to about 75, preferably about 40 to about 60, weight percent of said organosilane polysulfide compound and, correspondingly, (b) about 75 to about 25, preferably about 60 to about 40, weight percent particulate carbon black. A purpose of providing the high purity organosilane disulfide in a form of a particulate in the process of this invention is to add the high purity organosilane disulfide in a form of a relatively dry, or substantially dry, powder in which the carbon black acts as a carrier for the high purity organosilane disulfide in the process of this invention, since it is considered herein that the high purity disulfide would normally otherwise be in a liquid, or substantially liquid, form. A contemplated benefit for the particulate is to aid in the dispersing of the high purity organosilane disulfide in the preparatory mixing step(s) of the process of this invention and to aid in the introduction of the high purity disulfide into the preparatory mixing of the rubber composition mixture.

In further accordance with the invention, the process comprises the additional step of vulcanizing the prepared rubber composition at a temperature in a range of about 140° C. to about 190° C.

Accordingly, the invention also thereby contemplates a vulcanized rubber composition prepared by such process.

In additional accordance with the invention the process comprises the additional steps of preparing an assembly of a tire or sulfur vulcanizable rubber with a tread comprised of the said rubber composition prepared according to the process of this invention and vulcanizing the assembly at a temperature in a range of about 140° C. to about 190° C.

Accordingly, the invention also thereby contemplates a vulcanized tire prepared by such process.

In onc aspect of the invention, optionally a total of about 0.05 to about 5 phr of at least one alkyl silane can be thermomechanically mixed in said preparatory mixing stage(s), particularly where said alkyl silane has the formula: $R'—Si—(OR)_3$, where R is a methyl, ethyl, propyl or isopropyl radical and R' is a saturated alkyl radical having

from 1 to 18 carbon atoms, or an aryl or saturated alkyl substituted aryl radical having from 6 to 12 carbon atoms. Such aryl or substituted aryl radicals might be, for example, benzyl, phenyl, tolyl, methyl tolyl, and alpha methyl tolyl radicals.

A purposc of the alkyl silane is, for example, to improve filler incorporation and compound aging.. Representative examples of alkyl silanes are, for example but not intended to be limited to, propyltriethoxysilane, methyltriethoxy silane, hexadecyltriethoxysilane, and octadecyltriethoxysilane.

A particular feature of this invention is the creation of a silica coupler/particulate filler composition in situ within the rubber composition in its preparatory stage by the utilization of a relatively high purity organosilanc disulfide in combination with an addition of a sulfur source such as elemental sulfur and/or sulfur donor, and/or addition of a sulfur vulcanization accelerator which is not considered herein as a sulfur donor, in which the materials are thermomechanically mixed in at least one preparatory mixing stage to a temperature of about 140° C. to about 180° C. Indeed, by utilization of this process, it is conceivable that the rubber mixing process might the conducted at an even higher temperature range such as from about 140° C. to about 190° C.

This is considered to be a substantial departure from a practice of using, for example, 3,3'-bis(trialkoxyalkylsilyl)tetrasulfide or trisulfide in the absence of any other sulfur source in a non-productive rubber composition mixing stage at a temperature in a range of about 140° C. to about 180° C.

In the practice of the invention, the amount of sulfur, or sulfur releasable from a sulfur donor, introduced into the preparatory mixing is, generally, in a range of about 0.05 to about 2, alternatively about 0.2 to about 1. It is to bc appreciated that the addition of the sulfur is in the sense of decoupling the silane reaction of the organosilane polysulfide with the reaction of free sulfur released from thc polysulfide portion. This, according to the invention, is accomplished by utilizing a relatively high purity disulfide version which does not appreciably relcase free sulfur under the prescribed conditions so that sulfur can be separately added in the preparatory mixing in the form, for example, as free sulfur or from a sulfur donor. In this scnse, then, the contemplated amount of free sulfur which can be added in the preparatory mixing, in the practice of this invention, is, in general, somewhat comparable to the free sulfur which would have been generated from the organosilane polysulfide if it contained about 3–8 sulfur atoms in its sulfur bridge. While that actual calculation might be somewhat difficult to make since it would require an evaluation of the actual number sulfur atoms in the sulfur bridge, the range of sulfur added is more simply recited herein in terms of phr, or per hundred parts of rubber. This is believed to provide an appropriate amount of free sulfur addition for an organosilane polysulfide in which at least 80, alternatively at least 95, percent of n is 2 and the remainder of n is an integer of from 3 to about 8, namely, in which at least 80, alternatively at least 95, percent of the organosilane polysulfide is organosilane disulfide. As hercinbefore discussed, a sulfur vulcanization accelerator which is not considered herein as being a sulfur donor, can also be added, even as an alternative to the said sulfur source, in the preparatory mixing for the process of this invention. The practitioner having ordinary skill in the rubber mixing art can readily optimize a sulfur source addition for the preparatory mixing to accommodate a desired mixing and processing condition and resultant rubber composition properties.

In the practice of this invention, said sulfur donor for said preparatory stcp(s) is sclected from at least one of polysulfide vulcanization accelerator for sulfur vulcanizable elastomers and organosilane polysulfide with the polysulfide portion thereof composed of at least three connecting sulfur atoms organosilane.

For the said additionally added vulcanization accelerators as they may be referred to herein, it is appreciated that they may be, for example, of the type such as, for example, benzothiazole, alkyl thiuram disulfide, guanidine derivatives and thiocarbamates. Representative of such accelerators are, for example but not limited to, mercapto benzothiazole, tetramethyl thiuram disulfide, benzothiazole disulfide, diphenylguanidine, zinc dithiocarbamate, alkylphenoldisulfide, zinc butyl xanthate, N-dicyclohexyl-2-benzothiazolesulfenamide, N-cyclohexyl2-benzothiazolesulfenamide, N-oxydiethylenebenzothiazole-2-sulfenamide, N,N diphenylthiourea, dithiocarbamylesulfenamide, N,N diisopropylbezothiozole-2-sulfenamide, zinc-2-mercaptotoluimidazole, dithiobis (N methyl piperazine), dithiobis(N beta hydroxy ethyl piperazine) and dithiobis(dibenzyl amine). Such materials are understood herein to be well known as sulfur vulcanization accelerators for sulfur vulcanizable elastomers to those having skill in the rubber compounding art.

For additional sulfur donors, it is to be apprcciatcd that such donors may be, for example, of the type, for example, thiuram and morpholine derivatives. Representative of such donors arc, for example, but not limited to, dimorpholine disulfide, dimorpholine tetrasulfide, tetramethyl thiuram tetrasulfide, benzothiazyl-2,N dithiomorpholide, thioplasts, dipentamethylenethiurahexasulfide, and disulfidecaprolactame. Such materials are understood to be well known sulfur donors to those having skill in the rubber compounding art.

For said additional sulfur donors, organosilane polysulfides with three or more connecting sulfur atoms in the polysulfide bridge may be used, representative examples thereof, but not limited to are those such as, for example, 3,3'-bis(trimethoxylsilylpropyl) trisulfide and tetrasulfide, 3,3'-bis(triethoxysilylpropyl) trisulfide and tetrasulfide, 3,3'-bis(triethoxysilylethyltolylene) trisulfide and tetrasulfide, and polysulfide organosilane T47 from Huels AG.

Where it is desired for the rubber composition, which contains both a silicious filler such as silica, alumina and/or aluminosilicates and also carbon black reinforcing pigments, to be primarily reinforced with silica as the reinforcing pigmcnt, it is often preferable that the weight ratio of such silicious pigments silicates to carbon black is at least 3/1 and preferably at least 10/1 and, thus, in a range of about 3/1 to about 30/1.

In one aspect of the invention, it is preferred that the silicious pigment is precipitated silica.

In another aspect of the invention, the fillcr is comprised of about 15 to about 95 weight percent precipitated silica, alumina and/or aluminosilicate and, correspondingly, about 5 to about 85 weight percent carbon black; wherein the said carbon black has a CTAB value in a range of about 80 to about 150.

In a practice of this invention, said filler can be comprised of about 60 to about 95 weight percent of said silica, alumina and/or aluminosilicate and, correspondingly, about 40 to about 5 weight percent carbon black.

For the aforesaid organosilane disulfide compound, representative R^2 radicals are alkyl radicals and representative R^1 radicals are sclected from alkaryl, phenyl and haloaryl radicals.

Thus, in one aspect of the invention, the R^2 and R^1 radicals arc mutually exclusive.

Representative examples of alkyl radicals are methyl, ethyl, n-propyl and n-decyl radicals.

Representative examples of aralkyl radicals are benzyl and alpha, alpha dimethylbenzyl radicals.

Representative examples of alkaryl radicals are p-tolyl and p-nonylphenol radicals.

A representative example of a haloaryl radical is a p-chlorophenol radical.

Representative examples of organosilane disulfides of the aforesaid organosilane polysulfide compound include, for example:

2,2'-bis(trimethoxysilylethyl) disulfide;
3,3'-bis(trimethoxysilylpropyl) disulfide;
3,3'-bis(triethoxysilylpropyl) disulfide;
2,2'-bis(triethoxysilylpropyl) disulfide;
2,2'-bis(tripropoxysilylethyl) disulfide;
2,2'-bi(tri-sec.butoxysilylethyl) disulfidc;
3,3'-bis(tri-t-butoxyethyl) disulfide;
3,3'-bis(tricthoxysilylethyl tolylene) disulfide;
3,3'-bis(trimethoxysilylethyl tolylene) disulfide;
3,3'-bis(triisopropoxypropyl) disulfide;
3,3'-bis(trioctoxypropyl) disulfide;
2,2'-bis(2'-ethylhexoxysilylethyl) disulfide;
2,2'-bis(dimethoxy ethoxysilylethyl) disulfide;
3,3'-bis(methoxyethoxypropoxysilylpropyl) disulfide;
3,3'-bis(methoxy dimethylsilylpropyl) disulfide;
3,3'-bis(cyclohexoxy dimethylsilylpropyl) disulfide;
4,4'-bis(trimethoxysilylbutyl) disulfidc;
3,3'-bis(trimethoxysilyl-3-methylpropyl) disulfide;
3,3'-bis(tripropoxysilyl-3-methylpropyl)disulfide;
3,3'-bis(dimethoxy methylsilyl-3-cthylpropyl) disulfide; 3,3'-bis(trimethoxysilyl-2-methylpropyl) disulfide; 3,3'-bis(dimethoxyphenylsilyl-2-methylpropyl) disulfide; 3,3'-bis (trimcthoxysilylcyclohexyl) disulfide; 12,12'-bis (trimethoxysilyldodecyl) disulfide; 12,12'-bis (triethoxysilyldodecyl) disulfide; 18,18'-bis (trimethoxysilyloctadecyl) disulfide; 18,18'-bis (methoxydimethylsilyloctadecyl) disulfide; 2,2-'-bis (trimethoxysilyl-2-methylethyl) disulfide; 2,2'-bis (triethoxysilyl-2-methylethyl) disulfide; 2,2'-bis (tripropoxysilyl-2-methylethyl) disulfide; and 2,2'-bis(trioctoxysilyl-2-methylethyl) disulfide.

In the practice of this invention, as hereinbefore pointed out, the rubber composition is comprised of at least one diene-based elastomer, or rubber. Suitable conjugated dienes are isoprene and 1,3-butadiene and suitable vinyl aromatic compounds are styrene and alpha methyl styrene. Thus, it is considered that the elastomer is a sulfur curable elastomer. Such diene based clastomer, or rubber, may be selected, for example, from at least one of cis 1,4-polyisoprene rubber (natural and/or synthetic), and preferably natural rubber), emulsion polymerization prepared styrene/butadiene copolymer rubber, organic solution polymerization prepared styrene/butadiene rubber, 3,4-polyisoprene rubber, isoprene/butadiene rubber, styrene/isoprene/butadiene terpolymer rubbers, cis 1,4-polybutadiene, medium vinyl polybutadiene rubbcr (35–50 percent vinyl), high vinyl polybutadiene rubber (50–75 percent vinyl), styrene/isoprene copolymers, emulsion polymerization prepared styrene/butadiene/acrylonitrile terpolymer rubber and butadiene/acrylonitrile copolymer rubber.

In one aspect of this invention, an emulsion polymerization derived styrene/butadiene (E-SBR) might be used having a relatively conventional styrene content of about 20 to about 28 percent bound styrene or, for some applications, an E-SBR having a medium to relativcly high bound styrene content, namely, a bound styrene content of about 30 to about 45 percent.

The relatively high styrene content of about 30 to about 45 for the E-SBR might be considered beneficial for a purpose of enhancing traction, or skid resistance, of the tire tread. The presence of the E-SBR itself is considered beneficial for a purpose of enhancing processability of the uncured elastomer composition mixture, especially in comparison to a utilization of a solution polymerization prepared SBR (S-SBR).

By emulsion polymerization prepared E-SBR, it is meant that styrene and 1,3-butadiene are copolymerized as an aqueous emulsion. Such are well known to those skilled in such art. The bound styrene content can vary, for example, from about 5% to 50%. In one aspect, the E-SBR may also contain acrylonitrile to form a terpolymer rubber, as E-SBR, in amounts, for example, of about 2 to about 30 weight percent bound acrylonitrile in the terpolymer.

Emulsion polymerization prepared styrene/butadiene/acrylonitrile terpolymer rubbers containing about 2 to about 40 weight percent bound acrylonitrile in the terpolymer are also contemplated as diene based rubbers for use in this invention.

The solution polymerization prepared SBR (S-SBR) typically has a bound styrene content in a range of about 5 to about 50, preferably about 9 to about 36, percent. The S-SBR can be conveniently prepared, for example, by organo lithium catalyzation in the presence of an organic hydrocarbon solvent.

A purpose of using S-SBR is for improved tire rolling resistance as a result of lower hysteresis when it is used in a tire tread composition.

The 3,4-polyisoprene rubber (3,4-PI) is considered beneficial for a purpose of enhancing the tire's traction when it is used in a tire tread composition.

The 3,4-polyisoprene elastomer and use thereof is more fully described in U.S. Pat. No. 5,087,668 which is incorporated herein by reference.

The cis 1,4-polybutadiene rubber is considered to be beneficial for a purpose of enhancing the tire tread's wear, or treadwear.

Such polybutadiene elastomer can be prepared, for example, by organic solution polymcrization of 1,3-butadiene as is well known to those having skill in such art.

The polybutadiene elastomer may be conveniently characterized, for example, by having at least a 90% cis 1,4-content.

The cis 1,4-polyisoprene and cis 1,4-polyisoprene natural rubber are well known to those having skill in the rubber art.

The vulcanized rubber composition should contain a sufficient amount of silica, and carbon black if used, reinforcing filler(s) to contribute a reasonably high modulus and high resistance to tear. The combined weight of the silica, alumina, aluminosilicates and carbon black, as hereinbefore referenced, may be as low as about 30 parts per 100 parts rubber, but is more preferably from about 35 to about 90 parts by weight.

While it is considered herein that commonly employed siliceous pigments used in rubber compounding applications might be used as the silica in this invention, including pyrogenic and precipitated siliceous pigments (silica) alumina, aluminosilicates, precipitated silicas are preferred.

The siliceous pigments preferably employed in this invention are precipitated silicas such as, for example, those obtained by the acidification of a soluble silicate, e.g., sodium silicate. Such precipitated silicas are well known to those having skill in such art.

Such precipitated silicas might be characterized, for example, by having a BET surface area, as measured using nitrogen gas, preferably in the range of about 40 to about 600, and more usually in a range of about 50 to about 300 square meters per gram. The BET method of measuring surface area is described in the *Journal of the American Chemical Society*, Volume 60, page 304 (1930).

The silica may also be typically characterized by having a dibutylphthalate (DBP) absorption value in a range of about 100 to about 350, and more usually about 150 to about 300.

Further, the silica, as well as the aforesaid alumina and aluminosilicate may be expected to have a CTAB surface area in a range of about 100 to about 220. The CTAB surface area is the external surface area as evaluated by cetyl trimethylammonium bromide with a pH of 9. The method is described in ASTMD 3849 for set up and evaluation. The CTAB surface area is a well known means for characterization of silica.

Mercury surface area/porosity is the specific surface area determined by Mercury porosimetry. For such technique, mercury is penetrated into the pores of the sample after a thermal treatment to remove volatiles. Set up conditions may be suitably described as using a 100 mg sample; removing volatiles during 2 hours at 105° C. and ambient atmospheric pressure; ambient to 2000 bars pressure measuring range. Such evaluation may be performed according to the method described in Winslow, Shapiro in ASTM bulletin, p.39 (1959) or according to DIN 66133. For such an evaluation, a CARLO-ERBA Porosimeter 2000 might be used.

The average mercury porosity specific surface area for the silica should be in a range of about 100 to 300 m^2/g.

A suitable pore size distribution for the silica, alumina and aluminosilicate according to such mercury porosity evaluation is considered herein to be:

five percent or less of its pores have a diameter of less than about 10 nm; 60 to 90 percent of its pores have a diameter of about 10 to about 100 nm; 10 to 30 percent of its pores have a diameter of about 100 to about 1000 nm; and 5 to 20 percent of its pores have a diameter of greater than about 1000 nm.

The silica might be expected to have an average ultimate particle size, for example, in the range of 0.01 to 0.05 micron as determined by the electron microscope, although the silica particles may be even smaller, or possibly larger, in size.

Various commercially available silicas may be considered for use in this invention such as, only for example herein, and without limitation, silicas commercially available from PPG Industries under the Hi-Sil trademark with designations Hi-Sil 210, 243, etc; silicas available from Rhone-Poulenc, with, for example, designation of Zeosil 1165MP, silicas available from Degussa GmbH with, for example, designations VN2 and VN3, etc and silicas commercially available from Huber having, for example, a designation of Hubersil 8745.

Representative examples of alumina for the purposes of this invention are natural and synthetic aluminum oxide (Al_2O_3). Such alumina can be suitably synthetically prepared, for example, by controlled precipitation of aluminum hydroxide. For example, neutral, acidic, and basic Al_2O_3 can be obtained from the Aldrich Chemical Company. In the practice of this invention, the neutral alumina is preferred, however, it is considered herein that the acidic, basic and neutral forms of alumina could be used. The neutral, or substantially neutral form is indicated as being preferential in order to use a form with reduced number of surface —OH groups as compared to the acidic form and, also, to reduce the basic sites of the alumina which are AlO-ions, representing a strong base, in order to reduce potential interferences with the desired reactions of the alumina with the organosilane disulfide coupler.

Representative examples of aluminosilicates for the purposes of this invention are, for example but not intended to be limited to, Sepiolite as a natural aluminosilicate which might be obtained as PANSIL from Tolsa S.A., Toledo, Spain and SILTEG as a synthetic aluminosilicate from Degussa GmbH. Such aluminosilicates can be used as natural materials or synthetically prepared, for example, as hereinbefore exemplified.

It is readily understood by those having skill in the art that the rubber composition would be compounded by methods generally known in the rubber compounding art, such as mixing the various sulfur-vulcanizable constituent rubbers with various commonly used additive materials such as, for example, curing aids, such as sulfur, activators, retarders and accelerators, processing additives, such as oils, resins including tackifying resins, silicas, and plasticizers, fillers, pigments, fatty acid, zinc oxide, waxes, antioxidants and antiozonants, peptizing agents and reinforcing materials such as, for example, carbon black. As known to those skilled in the art, depending on the intended use of the sulfur vulcanizable and sulfur vulcanized material (rubbers), the additives mentioned above are selected and commonly used in conventional amounts.

Typical amounts of reinforcing type carbon blacks(s), for this invention, if used, are hereinbefore set forth. It is to be appreciated that the silica coupler may be used in conjunction with a carbon black, namely, pre-mixed with a carbon black prior to addition to the rubber composition, and such carbon black is to be included in the aforesaid amount of carbon black for the rubber composition formulation. Typical amounts of tackifier resins, if used, comprise about 0.5 to about 10 phr, usually about 1 to about 5 phr. Typical amounts of processing aids comprise about 1 to about 50 phr. Such processing aids can include, for example, aromatic, napthenic, and/or paraffinic processing oils. Typical amounts of antioxidants comprise about 1 to about 5 phr. Representative antioxidants may be, for example, diphenyl-p-phenylenediamine and others, such as, for example, those disclosed in the *Vanderbilt Rubber Handbook* (1978), pages 344–346. Typical amounts of antiozonants comprise about 1 to 5 phr. Typical amounts of fatty acids, if used, which can include stearic acid comprise about 0.5 to about 3 phr. Typical amounts of zinc oxide comprise about 2 to about 5 phr. Typical amounts of waxes comprise about 1 to about 5 phr. Often microcrystalline waxes are used. Typical amounts of peptizers comprise about 0.1 to about 1 phr. Typical peptizers may be, for example, pentachlorothiophenol and dibenzamidodiphenyl disulfide.

The vulcanization is conducted in the presence of a sulfur vulcanizing agent. Examples of suitable sulfur vulcanizing agents include, for example, elemental sulfur (free sulfur) or sulfur donating vulcanizing agents, for example, an amine disulfide, polymeric polysulfide or sulfur olefin adducts which are conventionally added in the final, productive, rubber composition mixing step. Preferably, in most cases, the sulfur vulcanizing agent is elemental sulfur. As known to those skilled in the art, sulfur vulcanizing agents are used, or added in the productive mixing stage, in an amount ranging from about 0.4 to about 3 phr, or even, in some circumstances, up to about 8 phr, with a range of from about 1.5 to about 2.5, sometimes from 2 to 2.5, being usually preferred.

Accelerators are used to control the time and/or temperature required for vulcanization and to improve the properties of the vulcanizate. In one embodiment, a single accelerator system may be used, i.e., primary accelerator. Conventionally and preferably, a primary accelerator(s) is used in total amounts ranging from about 0.5 to about 4, preferably about 0.8 to about 1.5, phr. In another embodiment, combinations of a primary and a secondary accelerator might be used with the secondary accelerator being used in smaller amounts (of about 0.05 to about 3 phr) in order to activate and to improve the properties of the vulcanizate. Combinations of these accelerators might be expected to produce a synergistic effect on the final properties and are somewhat better than those produced by use of either accelerator alone. In addition, delayed action accelerators may be used which are not affected by normal processing temperatures but produce a satisfactory cure at ordinary vulcanization temperatures. Vulcanization retarders might also be used. Suitable types of accelerators that may be used in the present invention are amines, disulfides, guanidines, thioureas, thiazoles, thiurams, sulfenamides, dithiocarbamates and xanthates. Preferably, the primary accelerator is a sulfenamide. If a second accelerator is used, the secondary accelerator is preferably a guanidine, dithiocarbamate or thiuram compound.

The rubber composition of this invention can be used for various purposes. For example, it can be used for various tire compounds. Such tires can be built, shaped, molded and cured by various methods which are known and will be readily apparent to those having skill in such art.

The invention may be better understood by reference to the following examples in which the parts and percentages are by weight unless otherwise indicated.

EXAMPLE 1

Sulfur vulcanizable rubber mixtures containing silica reinforcement were prepared utilizing, individually, both a 3,3-bis(triethoxysilylpropyl) tetrasulfide and by utilizing a high purity 3,3-bis(triethoxysilylpropyl) disulfide.

It is believed that said organosilane tetrasulfide sulfur bridge portion contains an average of about 3.5 to about 4 connecting sulfur atoms, with a range of about 2 to 6 or 8 connecting sulfur atoms, and with not more than 25 percent of its sulfur bridge portion having 2 or less connecting sulfur atoms.

The said organosilane polysulfide and the high purity organosilane disulfide were mixed with the elastomer(s) and compounding ingredients in a sequential step-wise manner in a series of preparatory mix stages.

For the use of the high purity 3,3-bis(triethoxysilylpropyl) disulfide, a small amount of free sulfur is also added in the first preparatory mix stage. In the final mix stage additional and a more quantitative amount of free sulfur is added together with sulfur vulcanization accelerators.

After each mixing step the rubber mixture was batched off on a mill, mill mixed for a short period of time, and slabs of rubber removed from the mill and allowed to cool to a temperature of about 30° C. or lower.

Rubber compositions containing the materials set out in Table 1 were prepared in a BR Banbury mixer using three separate stages of addition (mixing), namely, two preparatory mix stages and one final mix stage to temperatures of 160° C., 160° C. and 120° C. and times of about 8 minutes, 2 minutes and 2 minutes, respectively for the three overall mix stages. The amounts of the organosilane tetrasulfide, organosilane disulfide and free, elemental sulfur are listed as being "variable" in Table 1 and are more specifically set forth in Table 2.

Samples 2 and 3, which used the high purity organosilane disulfide, when compared to Sample 1 which used the organosilane polysulfide, clearly show the advantage of using the high purity organosilane disulfide in combination with the free sulfur addition as a means to control the mixing process for the silica reinforced elastomer.

TABLE 1

1st Preparatory Mixiog Stage	
Elastomer[1]	100
Processing Oil	14
Antioxidant[2]	10
Silica[3]	83
Bis-(3-triethoxysilylpropyl) tetrasulfide[4]	variable
Organosilane disulfide	variable
Sulfur[5]	variable
Final Mixing Stage	
Sulfur[5]	1.4
Accelerator, sulfenamide type	1.6
ZnO	3
Fatty Acid	2

[1]a combination of elastomers, namely, cis 1,4-polyisoprene natural rubber, E-SBR obtained from The Goodyear Tire & Rubber Company cootaining about 40 percent styrene and having a Tg of about −31° C., isoprene/butadiene (50/50) copolymer elastomers having a Tg of about -44° C. obtained from The Goodyear Tire & Rubber Company, and cis 1,4-polybutadiene elastomer obtaioed as BUD 1207 from The Goodyear Tire & Rubber Company, in a dry rubber weight ratio of 10/25/45/20; with the E-SBR being oil extended so that it contaios 25 phr rubber and 15 phr oil.

[2]a pheoyleoe dismine type;

[3]Zeosil 1165 MP from Rhone Poulenc;

[4]a composite commercially available from Degussa GmbH as X50S io a form of a 50/50 blend of Si69, or what might be referred to as bis-(3-triethoxysilylpropyl)tetrasulfide as hereinbefore described in this specification, (said tetrasulfide also available from Degussa GmbH as Si69), with carbon black and, thus, the tetrasulfide is considered as being 50% of the composite and, therefore, 50% active; and

[5]obtained as an S_8 elemental sulfur from the Kali Chemie company of Germany.

The high purity organosilane disulfide can be suitably prepared, for example, by oxidation of mercapto propyltriethoxysilane on manganese dioxide under conditions such as adding 500 parts by weight of the mercaptosilane to about 320 parts by weight of manganese dioxide and the mixture shaken vigorously. The reaction initially takes place at about room temperature, or about 23° C., which then rises to about 90° C. due to the exothermic reaction process. About 500 parts by weight of dry toluene are then added. The mixture is allowed to continue to react at about 50° C. for about an hour. Manganese dioxide is then removed by filtration and the remaining organic phase is filtered.

The purity of the organosilane disulfide was determined to be at least 98 percent by weight. Thus, for the organosilane polysulfide compound used in the process for this Example, the value for at least 98 percent of n was 2. The purity was measured by NMR (nuclear magnetic resonance verified and by (i) GC-MS, or gas chromatography mass spectrometry, and (ii) HPLC, or high performance liquid chromatography.

TABLE 2

Sample #	Ex 1	Ex 2	Ex 3
Bis-(3-triethoxysilyl-propyl)tetrasulfide	13.6		
Organosilane disulfide		10	8

TABLE 2-continued

Sample #	Ex 1	Ex 2	Ex 3
Sulfur[1]			0.87
Mooney NP1[2]	113	100	104
Mooney NP2[3]	97	89	95
Mooney P[4]	53	47	51
Mooney Peak Value[5] (NP1)	130	115	119
Rheometer (150° C.)			
Max. Torque	14.2	12.3	14.2
Min. Torque	3.2	2.3	3.7
Delta Torque	11	10	11.2
T_{90}, minutes	5.5	4.1	4.7
Stress-Strain			
Tensile Strength, MPa	16	17.2	17
Elongation at Break, %	411	532	453
100% Modulus, MPa	1.87	1.6	1.6
300% Modulus, MPa	10.9	7.8	10.7
Rebound			
100° C., %	68.4	63.4	67.2
Hardness			
25° C.	60	67.3	63.2
Dynaliser			
Tan Delta at 60° C.	0.079	0.100	0.080
DIN Abrasion	87	65	81

[1]sulfur added in the preparatory, non-productive mix stage;
[2,3,4]Mooney viscosity (ML-4) of the rubber mixture from the non-productive mix stage No. 1 and No. 2 (NP1 and NP2) and productive mix stage (P), respectively; and
[5]the Mooney (ML-4) peak value for the rubber mixture from the NP1 mix stage means the maximum Mooney value determined from the Mooney curve plotted as Mooney versus time.

In particular, this Example shows that high purity organosilane disulfide plus the controlled addition of a very small amount of free sulfur, namely, in an amount similar to the estimated free sulfur that would have been generated in the mixing step if the organosilane tetrasulfide had been used (Ex. 3), provides a rubber composition with properties somewhat similar to the properties of the rubber composition of Ex. 1 which utilized the organosilane tetrasulfide.

This Example further shows that controlling the amount of free sulfur in the non-productive rubber mix stage is beneficial to the rubber compound processing control at equivalent properties as particularly evidenced by Ex. 1 versus Ex. 3. In one aspect, the DIN Abrasion property of Ex. 2 is significantly lower than that of both Ex. 1 and Ex. 3. While this may be considered an advantage in using the organosilane disulfide without the controlled addition of the free sulfur because such property is sometime considered indicative of tire treadwear. Nevertheless the utilization of the free sulfur in the rubber mixture of Ex.3. is still considered an advantage because tire rolling resistance property is considered to be improved as demonstrated by the hot rebound and tan.delta values.

In addition, the Mooncy plasticity values, as a measure of the viscosity of the rubber mixture, emphasizes the advantage of using disulfide without the free sulfur addition as compared to using the organosilane tetrasulfide as far as compound processing is concerned as demonstrated by the Mooney values shown in Table 2 and particularly the Mooney peak values of the rubber from the non-productive mix stages with the values being progressively greater from Ex. 2 to Ex. 3 to Ex. 1.

Accordingly, it is considered herein that it has been demonstrated that, in the mixing of sulfur vulcanizable elastomer, silica, and organosilane polysulfide coupler at an elevated temperature, a method has been provided for decoupling (i) the formation of a covalent bond between the organosilane polysulfide and the elastomer (the aforesaid second reaction) from (ii) the sulfur donating effect (the aforesaid third reaction).

EXAMPLE II

Tires of size 195/65R15 wcre preparcd using thc rubbcr compositions of Exs. 1, 2 and 3 for the treads thereof. The following results were obtained as shown in Table 3:

TALBE 3

	Ex. 1	Ex. 2	Ex. 3
Rolling Resistance	100	96	100
High Speed[1] Km/h	2'46"/270	3'07"/280	8'15"/270
Treadwear	100	111	101
Wet skid on asphalt	100	105	99
Wet skid on concrete	100	103	103

[1]The high speed values are given, for example, using the reported values for Ex. 3 as 8'15"/270 which means that the tire withstands 8 minutes and 15 seconds at 270 km/hr of equivalent vehicular speed (not rotational speed) on a suitable dynamometer.

This Example demonstrates that a tire with a tread of the rubbcr composition of Ex. 3 was observed to provide tire rolling resistance and treadwear similar to the tire with tread of the rubber composition of Ex. 1.

Thc utilization of a tirc with tread of Ex.3. is considered herein to be an advantage because it shows the best balance of properties, namely, wet skid, treadwear and rolling resistance at improved unvulcanized compound processing compared to Ex. 1 even though Ex. 2 did indicate a higher treadwear and better wet skid on asphalt values.

While certain representative embodiments and details have been shown for the purpose of illustrating the invention, it will be apparent to those skilled in this art that various changes and modifications may be made therein without departing from the spirit or scope of the invention.

What is claimed is:

1. A process of preparing a rubber composition which comprises the sequential steps of:

(A) thermomechanically mixing in at least one preparatory mixing step to a temperature of about 140° C. to about 190° C. for a total mixing time of about 2 to about 20 minutes (i) 100 parts by weight of at least one sulfur vulcanizable elastomer selected from conjugated diene homopolymers and copolymers and copolymers of at least one conjugated diene and aromatic vinyl compound, (ii) about 15 to about 100 phr of particulate filler comprised of at least one of precipitated silica, alumina, aluminosilicate and carbon black, wherein said filler contains from about 5 to about to 85 weight percent carbon black, (iii) about 0.05 to about 20 parts by weight per part by weight of said particulate filler of at least one organosilane polysulfide compound having the formula:

$$Z—R^1—S_n—R^1—Z$$

wherein n is an integer of from 2 to 8 provided, however, that at lcast 80 pcrcent of n is 2;

wherein Z is selected from the group consisting of:

$$
\begin{array}{c} R^2 \\ | \\ -Si-R^2 \\ | \\ R^3 \end{array}
\quad
\begin{array}{c} R^2 \\ | \\ -Si-R^3 \\ | \\ R^3 \end{array}
\quad \text{and} \quad
\begin{array}{c} R^3 \\ | \\ -Si-R^3 \\ | \\ R^3 \end{array}
$$

wherein R^2 may be the same or different and is individually selected from the group consisting of alkyl group having 1 to 4 carbons and phenyl; R^3 may be the same or different and is individually selected from the group consisting of alkyl groups having 1 to 4 carbon atoms, phenyl, alkoxy groups having 1 to 8 carbon atoms and cycloalkoxy groups with 5 to 8 carbon atoms; and R^1 is selected from the group consisting of a substituted or unsubstituted alkylene group having a total of 1 to 18 carbon atoms and a substituted or unsubstituted arylene group having a total of 6 to 12 carbon atoms;

(iv) at least one additional additive, exclusive of said organosilane polysulfide (iii) having at least 80 percent of n being 2, as a compound selected from (a) a free sulfur source selected from at least one of (1) elemental sulfur and (2) at least one sulfur donor as a polysulfidic organic compound containing sulfur and having a property of releasing at least a portion of said sulfur at a temperature in a range of about 140° C. to about 190° C.; provided, however, that the total free sulfur from said elemental sulfur addition and available from said sulfur donor addition is in a range of about 0.05 to about 2 phr, and (b) about 0.1 to about 0.5 phr of at least one vulcanization accelerator for sulfur vulcanizable elastomers that is not a such a sulfur donor; and

(B) subsequently blending therewith, in a final thermomechanical mixing step at a temperature to about 100° C. to about 130° C. for a time of about 1 to about 3 minutes, about 0.4 to about 3 phr of elemental sulfur provided, however that the total of elemental and/or free sulfur introduced in said preparatory mixing steps and elemental sulfur added in said final mixing step is in a range of about 0.45 to about 5 phr, and at least one sulfur vulcanization accelerator.

2. The process of claim **1** in which a total of about 0.05 to about 5 phr of at least one alkyl silane is added to said preparatory thermomechanical mixing step(s), wherein said alkyl silane has the formula: $R'-Si-(OR)_3$, where R is a methyl, ethyl, propyl or isopropyl radical and R' is a saturated alkyl having from 1 to 18 carbon atoms or aryl or saturated alkyl substituted aryl radical having from 6 to 12 carbon atoms.

3. The process of claim **2** wherein said alkyl silane is selected from one or more of propyltriethoxy silane, methyltriethoxy silane, hexadecyltriethoxy silane and octadecyltriethoxy silane.

4. The process of claim **1** wherein said preparatory mixing is conducted in at least two thermomechanical mixing steps, wherein at least two of such mixing steps are to a temperature of about 140° C. to about 190° C., with intermediate cooling of the rubber composition between at least two of the said mixing steps to a temperature below about 50° C.

5. The process of claim **1** which comprises the additional step of vulcanizing the prepared rubber composition at a temperature in a range of from about 140° C. to about 190° C.

6. A vulcanized rubber composition prepared according to the process of claim **5**.

7. The process of claim **1** which comprises the additional steps of preparing an assembly of a tire of sulfur vulcanizable rubber with a tread comprised of the said rubber composition and vulcanizing the assembly at a temperature in a range of about 140° C. to about 190° C.

8. A vulcanized rubber tire prepared according to the process of claim **7**.

9. The process of claim **4** which comprises the additional step of vulcanizing the prepared rubber composition at a temperature in a range of from about 140° C. to about 190° C.

10. A vulcanized rubber composition prepared according to the process of claim **9**.

11. The process of claim 4 which comprises the additional steps of preparing an assembly of a tire of sulfur vulcanizable rubber with a tread comprised of the said rubber composition and vulcanizing the assembly at a temperature in a range of about 140° C. to about 190° C.

12. A vulcanized rubber tire prepared according to the process of claim **11**.

13. The process of claim **1** where, for said sulfur vulcanizable elastomer, said conjugated dienes are selected from isoprene and 1,3-butadiene and said vinyl aromatic compounds are selected from styrene and alpha methyl styrene.

14. The process of claim **1** where said sulfur vulcanizable elastomer is selected from at least one of natural and synthetic cis 1,4-polyisoprene rubber, emulsion polymerization prepared styrene/butadiene copolymer rubber, organic solution polymerization prepared styrene/butadiene copolymer rubber, 3,4-polyisoprene rubber, isoprene/butadiene rubber, styrene/isoprene/butadiene terpolymer rubbers, cis 1,4-polybutadiene rubber, medium vinyl polybutadiene rubber (35–50 percent vinyl), high vinyl polybutadiene (50–75 percent vinyl) and emulsion polymerization prepared styrene/butadiene/acrylonitrile terpolymer rubber and butadiene/acrylonitrile copolymer rubber.

15. The process of claim **1** wherein the silica is characterized by having a BET surface area in a range of about 100 to about 300 square meters per gram and a dibutylphthalate (DBP) absorption value in a range of about 150 to about 350, a CTAB value in a range of about 100 to about 220, and a mercury porosimetry pore size distribution of: five percent less of its pores with a diameter of less than about 10 nm; 60 to 90 percent of its pores with a diameter of about 10 to about 100 nm; 10 to 30 percent of its pores with a diameter of about 100 to about 1000 run and 5 to 20 percent of its pores with a diameter of greater than about 1000 nm.

16. The process according to claim **15** in which said filler is comprised of about 15 to about 95 weight percent precipitated silica and, correspondingly, from 5 to about 85 weight percent carbon black; wherein said carbon black is has a CTAB value in a range of about 80 to about 150.

17. The process according to claim **16** wherein the filler is comprised of about 60 to about 95 weight percent silica and, correspondingly, about 40 to about 5 weight percent carbon black.

18. The process of claim **1** wherein said filler is comprised of about 15 to about 100 weight percent alumina and, correspondingly, from 5 to about 85 weight percent carbon black; wherein said carbon black has a CTAB value in a range of about 80 to about 150 and said alumina has a CTAB value in a range of about 100 to about 220 and a mercury porosimetry pore size distribution of: five percent less of its pores with a diameter of less than about 10 nm; 60 to 90 percent of its pores with a diameter of about 10 to about 100 nm; 10 to 30 percent of its pores with a diameter of about 100 to about 1000 nm and 5 to 20 percent of its pores with a diameter of greater than about 1000 nm.

19. The process according to of claim **18** wherein said filler is comprised of about 60 to about 95 weight percent

alumina and, correspondingly, about 40 to about 5 weight percent carbon black.

20. The process of claim 1 wherein said filler is comprised of about 15 to about 100 weight percent aluminosilicate and, correspondingly, from about 5 to about 85 weight percent carbon black; wherein said carbon black has a CTAB in a range of about 80 to about 150 and wherein said aluminosilicate has a CTAB value in a range of about 100 to about 220 and a mercury porosimetry pore size distribution of: five percent less of its pores with a diameter of less than about 10 nm; 60 to 90 percent of its pores with a diameter of about 10 to about 100 nm; 10 to 30 percent of its pores with a diameter of about 100 to about 1000 nm and 5 to 20 percent of its pores with a diameter of greater than about 1000 nm.

21. The process according to claim 20 wherein said filler is comprised of about 60 to about 95 weight percent aluminosilicate and, correspondingly, about 40 to about 5 weight percent carbon black.

22. The process of claim 1 where said aluminosilicate is selected from at least one of at least one of (a) natural aluminosilicates selected from Muscovite, Beryl, Dichroite, Sepiolite and Kaolinire and (b) synthetic aluminosilicates prepared by (i) coprecipitation by pH adjustment of a basic solution, or mixture of silicate and aluminate or by (ii) a chemical reaction between silanols at the surface of a silicon dioxide and $NaAlO_2$.

23. Thc proccss according to claim 22 wherc for said synthetic coprecipitated aluminosilicate about 5 to about 95 percent of its surface is composed of silica moieties and, correspondingly, about 95 to about 5 percent of its surface is composed of aluminum moieties.

24. The process according to claim 20 wherein said synthetic aluminosilicate is represented by the formula selected from: $[(Al_2O_3)_x.(SiO_2)_y.(H_2O)_z]$ and/or $[(Al_2O_3)_x.(SiO_2)_y.MO]$; where M is magnesium or calcium.

25. The process of claim 1 wherein said sulfur donor additional additive is selected from at least one of dimorpholine tetrasulfide, tetramethyl thiuram tetrasulfide, benzothiazyl-2,N dithiomorpholide, thioplasts, dipentamethylenethiuramhexasulfide and disulfidecaprolactame.

26. The process of claim 1 wherein said vulcanization accelerator for sulfur vulcanizable elastomers additional additivc is selected from at least one of mercaptobenzothiazole, tetramethyl thiuram disulfide, benzothiazole disulfide, diphenylguanidine, zinc dithiocarbamate, alkylphenoldisulfide, zinc butyl xanthate, N-dicyclohexyl-2-benzothiazolesulfenamide, N-cyclohexyl-2-benzothiazolesulfenamide, N-oxydiethylenebenzothiazole-2-sulfenamide, N,N diphenylthiourea, dithiocarbamylesulfenamide, N,N diisopropylbezothiozole-2-sulfenamide, zinc-2-mercaptotoluimidazole, dithiobis (N methyl piperazine), dithiobis(N beta hydroxy ethyl piperazine) and dithiobis(dibenzyl amine).

27. The process of claim 1 wherein said sulfur donor additional additive (iv) is exclusive of said organosilane polysulfide (iii) having at least 80 percent of n being 2 and is selected from at least one of 3,3'-bis(trimethoxysilylpropyl) trisulfidc and tetrasulfide; 3,3 '-bis(triethoxysilylpropyl) trisulfide and tetrasulfide; 3,3'-bis(triethoxysilylethyl tolylene) trisulfide and tetrasulfide; and 3,3'-bis(trimethoxysilylethyl tolylene) trisulfide and tetrasulfide.

28. The process of claim 1 wherein for the said organosilane polysulfide compound, said R^2 radicals are alkyl radicals and said R^1 radicals are selected from alkaryl, phenyl and haloaryl radicals.

29. The process according to claim 28 wherein said alkyl radicals are selected from methyl, ethyl, n-propyl and n-decyl radicals; said aralkyl radicals are selected from benzyl and alpha, alpha dimethylbenzyl radicals; said alkaryl radicals are selected from p-tolyl and p-nonylphenol radicals; and said haloaryl radical is a p-chlorophenol radical.

30. The process of claim 1 wherein organosilane disulfides of said organosilane polysulfide compounds are selccted from at lcast one of:

2,2'-bis(trimethoxysilylethyl) disulfide;

3,3'-bis(trimethoxysilylpropyl) disulfide;

3,3'-bis(triethoxysilylpropyl) disulfide;

2,2'-bis(triethoxysilylpropyl) disulfide;

2,2'-bis(tripropoxysilylethyl) disulfide;

2,2'-bi(tri-sec.butoxysilylethyl) disulfide;

3,3'-bis(tri-t-butoxyethyl) disulfide;

3,3'-bis(triethoxysilylethyl tolylene) disulfide;

3,3'-bis(trimethoxysilylethyl tolylene) disulfide;

3,3'-bis(triisopropoxypropyl) disulfide;

3,3'-bis(trioctoxypropyl) disulfide;

2,2'-his(2'-ethylhcxoxysilylethyl) disulfide;

2,2'-bis(dimethoxy ethoxysilylethyl) disulfide;

3,3'-bis(methoxyethoxypropoxysilylpropyl) disulfide;

3,3'-bis(methoxy dimethylsilylpropyl) disulfide;

3,3'-bis(cyclohexoxy dimethylsilylpropyl) disulfide;

4,4'-bis(trimethoxysilylbutyl) disulfide;

3,3'-bis(trimethoxysilyl-3-methylpropyl) disulfide;

3,3'-bis(tripropoxysilyl-3-methylpropyl)disulfide;

3,3 '-bis(dimethoxy methylsilyl-3-ethylpropyl) disulfide;

3,3 '-bis(trimethoxysilyl-2-methylpropyl) disulfide;

3,3'-bis(dimethoxyphenylsilyl-2-methylpropyl) disulfide;

3,3'-bis (trimethoxysilylcyclohexyl) disulfide;

12,12'-bis (trimethoxysilyldodecyl) disulfide;

12,12'-bis (triethoxysilyldodecyl) disulfide;

18,18'-his (trimethoxysilyloctadecyl) disulfide;

18,18'-bis (methoxydimethylsilyloctadecyl) disulfide;

2,2-'-his (trimethoxysilyl-2-methylethyl) disulfide;

2,2'-bis (triethoxysilyl-2-methylethyl) disulfide;

2,2'-bis (tripropoxysilyl-2-methylethyl) disulfide; and

2,2'-bis(trioctoxysilyl-2-methylethyl) disulfide.

31. The process of claim 1 where organosilane disulfides of said organosilane polysulfide compounds are selected from at least one of:

3,3'-bis(trimethoxysilylpropyl) disulfide;

3,3'-bis(triethoxysilylpropyl) disulfide;

3,3'-bis(triethoxysilylethyl tolylene) disulfide; and

3,3'-bis(trimethoxysilylethyl tolylene) disulfide.

32. The process of claim 1 where, for said organosilane polysulfide, at least 95 percent of n is 2; where said R^2 radicals arc alkyl radicals selected from methyl, ethyl, n-propyl and n-decyl radicals; and where said R^1 radicals are selected from benzyl, alpha, alpha dimethylbenzyl, p-tolyl, p-nonylphenol and p-chlorophenol radicals.

33. The process according to claim 32 where the organosilane disulfides of said organosilane polysulfide compounds are selected from at least one of:

3,3'-bis(trimethoxysilylpropyl) disulfide;

3,3'-bis(triethoxysilylpropyl) disulfide;

3,3'-bis(triethoxysilylethyl tolylene) disulfide; and

3,3'-bis(trimethoxysilylethyl tolylene) disulfide.

34. The process of claim 1 wherein said organosilane disulfide of said organosilane polysulfide compound (iii) is selected from at least one of

3,3'-bis(trimethoxysilylpropyl) disulfide;

3,3'-bis(triethoxysilylpropyl) disulfide;

3,3'-bis(triethoxysilylethyl tolylene) disulfide; and

3,3'-bis(trimethoxysilylethyl tolylene) disulfide; where said carbon black has a CTAB value in a range of about 80 to about 150 and said silica, alumina and aluminosilicate have a BET surface area in a range of about 100 to about 300 square meters per gram, a dibutylphthalate (DBP) absorption value in a range of about 150 to about 350, a CTAB value in a range of about 100 to about 220 and has a mercury porosimetry pore size distribution of: five percent less of its pores with a diameter of less than about 10 nm; 60 to 90 percent of its pores with a diameter of about 10 to about 100 nm; 10 to 30 percent of its pores with a diameter of about 100 to about 1000 nm and 5 to 20 percent of its pores with a diameter of greater than about 1000 nm.; wherein said sulfur donor additional additive is selected from at least one of dimorpholine disulfide, dimorpholine tetrasulfide, tetramethyl thiuram tetrasulfide, benzothiazyl-2,N dithiomorpholide, thioplasts, dipentamethylenethiuramhexasulfide and disulfidecaprolactame; wherein said vulcanization accelerator for sulfur vulcanizable elastomers additional additive is selected from at least one of mercaptobenzothiazole, tetramethyl thiuram disulfide, benzothiazole disulfide, diphenylguanidine, zinc dithiocarbamate, alkylphenoldisulfide, zinc butyl xanthate, N-dicyclohexyl-2-benzothiazolesulfenamide, N-cyclohexyl-2-benzothiazolesulfenamide, N-oxydiethylenebenzothiazole-2-sulfenamide, N,N diphenylthiourea, dithiocarbamylesulfenamide, N,N diisopropylbezothiozole-2-sulfenamide, zinc-2-mercaptotoluimidazole, dithiobis (N methyl piperazine), dithiobis(N beta hydroxy ethyl piperazine) and dithiobis(dibenzyl amine); and wherein said organosilane polysulfide additional additive is selected from at least one of 3,3'-bis(trimethoxysilylpropyl) trisulfide and tetrasulfide; 3,3'-bis(triethoxysilylpropyl) trisulfide and tetrasulfide; 3,3'-bis(triethoxysilylethyl tolylene) trisulfide and tetrasulfide; and 3,3 '-bis(trimethoxysilylethyl tolylene) trisulfide and tetrasulfide.

35. The proccss according to claim **34** which comprises the additional step of vulcanizing the prepared rubber composition at a temperature in a range of from about 140° C. to about 190° C.

36. A rubber composition prepared according to the process of claim **35**.

37. The process according to claim **34** which comprises the additional steps of preparing an assembly of a tire of sulfur vulcanizable rubber with a tread comprised of the said rubber composition and vulcanizing the assembly at a temperature in a range of about 140° C. to about 190° C.

38. A tire prepared according to the process of claim **37**.

39. The process according to claim **4** where, for said sulfur vulcanizable elastomer, said conjugated dienes are selected from isoprene and 1,3-butadiene and said vinyl aromatic compounds are selected from styrene and alpha methyl styrene.

40. The process according to claim **4** where the sulfur vulcanizable elastomer is selected from at least one of natural and synthetic cis 1,4-polyisoprene rubber, emulsion polymerization prepared styrene/butadiene copolymer rubber, organic solution polymerization prepared styrene/butadienc copolymer rubber, 3,4-polyisoprene rubber, isoprene/butadiene rubber, styrene/isoprene/butadiene terpolymer rubbers, cis 1,4-polybutadiene rubber, and emulsion polymerization prcparcd styrene/butadiene/acrylonitrile terpolymer rubber and butadiene/acrylonitrile copolymer rubber.

41. The process according to claim **4** wherein the silica is characterized by having a BET surface area in a range of about 100 to about 300 square meters per gram and a dibutylphthalate (DBP) absorption value in a range of about 150 to about 350, a CTAB value in a range of about 100 to about 220, and a mercury porosimetry pore size distribution of: five percent less of its pores with a diameter of less than about 10 nm; 60 to 90 percent of its pores with a diameter of about 10 to about 100 nm; 10 to 30 percent of its pores with a diameter of about 100 to about 1000 nm and 5 to 20 percent of its pores with a diamcter of greater than about 1000 nm.

42. The process according to claim **41** in which said filler is comprised of about 15 to about 100 weight percent precipitated silica and, correspondingly, from 5 to about 85 weight percent carbon black; wherein said carbon black is has a CTAB value in a range of about 80 to about 150.

43. The process according to claim **42** wherein the filler is comprised of about 60 to about 95 weight percent silica and, correspondingly, about 40 to about 5 weight percent carbon black.

44. The process according to claim **4** wherein said filler is comprised of about 15 to about 100 weight percent alumina and, correspondingly, from 5 to about 85 weight percent carbon black; wherein said carbon black has a CTAB value in a range of about 80 to about 150 and said alumina has a CTAB value in a range of about 100 to about 220, and a mercury porosimetry pore size distribution of: five percent lcss of its pores with a diameter of less than about 10 nm; 60 to 90 percent of its pores with a diameter of about 10 to about 100 nm; 10 to 30 percent of its pores with a diameter of about 100 to about 1000 nm and 5 to 20 percent of its pores with a diameter of greater than about 1000 nm.

45. The process according to claim **44** wherein said filler is comprised of about 60 to about 95 weight percent alumina and, correspondingly, about 40 to about 5 weight percent carbon black.

46. The process according to claim **4** wherein said filler is comprised of about 15 to about 100 weight percent aluminosilicate and, correspondingly, from about 5 to about 85 weight percent carbon black; wherein said carbon black has a CTAB in a range of about 80 to about 150 and wherein said aluminosilicate has a CTAB value in a range of about 100 to about 220, and a mercury porosimetry pore size distribution of: five percent less of its pores with a diameter of less than about 10 nm; 60 to 90 percent of its pores with a diameter of about 10 to about 100 nm; 10 to 30 percent of its pores with a diameter of about 100 to about 1000 nm and 5 to 20 percent of its pores with a diameter of greater than about 1000 nm.

47. The process according to claim **46** wherein said filler is comprised of about 60 to about 95 weight percent aluminosilicate and, correspondingly, about 40 to about 5 weight percent carbon black.

48. The process according to claim **46** where said aluminosilicate is selected from at least one of at least one of (a) natural aluminosilicates selected from Muscovite, Beryl, Dichroite, Sepiolite and Kaolinire and (b) synthetic aluminosilicates prepared by (i) coprecipitation of a basic solution, or mixture of silicate and aluminate or by (ii) a chemical reaction between silanols of a silicon dioxide and $NaAlO_2$.

49. The process according to claim **48** where for said synthetic aluminosilicate about 5 to about 95 percent of its surface is composed of silica moieties and, correspondingly, about 95 to about 5 percent of its surface is composed of aluminum moieties.

50. The process according to claim 46 where said synthetic aluminosilicate is represented by the formula selected from: $[(Al_2O_3)_x.(SiO_2)_y.(H_2O)_z]$ and/or $[(Al_2O_3)_x.(SiO_2)_y.MO]$; where M is magnesium or calcium.

51. The process according to claim 4 wherein said sulfur donor additional additivc is selected from at least one of dimorpholine tetrasulfide, tetramethyl thiuram tetrasulfide, benzothiazyl-2,N dithiomorpholide, thioplasts, dipentamethylenethiuramhcxasulfidc and disulfidecaprolactame.

52. The process according to claim 4 wherein said vulcanization accelerator for sulfur vulcanizable elastomers additional additivc is sclcctcd from at least one of mercaptobenzothiazole, tetramethyl thiuram disulfide, benzothiazole disulfide, diphenylguanidine, zinc dithiocarbamate, alkylphcnoldisulfide, zinc butyl xanthate, N-dicyclohexyl-2-benzothiazolesulfenamide, N-cyclohexyl-2-benzothiazolesulfenamide, N-oxydiethylenebenzothiazole-2-sulfenamide, N,N diphenylthiourea, dithiocarbamylesulfenamide, N,N diisopropylbezothiozole-2-sulfenamide, zinc-2-mercaptotoluimidazole, dithiobis (N methyl piperazine), dithiobis(N beta hydroxy ethyl piperazine) and dithiobis(dibenzyl amine).

53. The process according to claim 4 wherein said sulfur donor additional additive (iv) is exclusive of said organosilane polysulfide (iii) having at least 80 percent of n being 2 and is selected from at least one of 3,3'-bis(trimethoxysilylpropyl) trisulfide and tetrasulfide; 3,3'-bis(triethoxysilylpropyl) trisulfide and tetrasulfide; 3,3'-bis(triethoxysilylethyl tolylene) trisulfide and tetrasulfidc; and 3,3'-bis(trimethoxysilylethyl tolylene) trisulfide and tetrasulfide.

54. The process according to claim 4 wherein for the said organosilane polysulfide compound, said R^2 radicals are alkyl radicals and said R^1 radicals are selected from alkaryl, phenyl and haloaryl radicals.

55. The process according to claim 54 wherein said alkyl radicals are selected from methyl, ethyl, n-propyl and n-decyl radicals; said aralkyl radicals are selected from benzyl and alpha, alpha dimethylbenzyl radicals; said alkaryl radicals are selected from p-tolyl and p-nonylphenol radicals; and said haloaryl radical is a p-chlorophenol radical.

56. The process according to claim 4 wherein organosilane disulfides of said organosilane polysulfide compounds are selected from at least one of:

2,2'-bis(trimethoxysilylethyl) disulfide;

3,3'-bis(trimethoxysilylpropyl) disulfide; disulfide;

3,3'-bis(triethoxysilylpropyl) disulfide;

2,2'-bis(triethoxysilylpropyl) disulfide;

2,2'-bis(tripropoxysilylethyl)

2,2'-bi(tri-sec.butoxysilylethyl) disulfide;

3,3'-bis(tri-t-butoxyethyl) disulfide;

3,3'-bis(triethoxysilylethyl tolylene) disulfide;

3,3,-bis(trimethoxysilylethyl tolylenc) disulfidc;

3,3'-bis(triisopropoxypropyl) disulfide;

3,3'-bis(trioctoxypropyl) disulfide;

2,2'-bis(2'-ethylhexoxysilylethyl) disulfide;

2,2'-bis(dimethoxy ethoxysilylethyl) disulfide;

3,3'-bis(methoxycthoxypropoxysilylpropyl) disulfide;

3,3'-bis(methoxy dimethylsilylpropyl) disulfide;

3,3'-bis(cyclohexoxy dimethylsilylpropyl) disulfide;

4,4'-bis(trimethoxysilylbutyl) disulfide;

3,3'-bis(trimethoxysilyl-3-methylpropyl) disulfide;

3,3'-bis(tripropoxysilyl-3-mcthylpropyl)disulfide;

3,3'-bis(dimethoxy methylsilyl-3-ethylpropyl) disulfide;

3,3'-bis(trimethoxysilyl-2-methylpropyl) disulfide;

3,3'-bis(dimethoxyphenylsilyl-2-methylpropyl) disulfide;

3,3'-bis (trimethoxysilylcyclohexyl) disulfide;

12,12'-bis (trimethoxysilyldodecyl) disulfide;

12,12'-bis (triethoxysilyldodecyl) disulfide;

18,18'-bis (trimethoxysilyloctadecyl) disulfide;

18,18'-bis (methoxydimethylsilyloctadecyl) disulfide;

2,2-'-bis (trimethoxysilyl-2-methylethyl) disulfide;

2,2'-bis (triethoxysilyl-2-methylethyl) disulfide;

2,2'-bis (tripropoxysilyl-2-methylethyl) disulfide; and

2,2'-bis(trioctoxysilyl-2-methylethyl) disulfide.

57. The process according to claim 4 where organosilane disulfides of said organosilanc polysulfidc compounds arc selected from at least one of:

3,3'-bis(trimethoxysilylpropyl) disulfide;

3,3'-bis(triethoxysilylpropyl) disulfide;

3,3'-bis(triethoxysilylethyl tolylene) disulfide; and

3,3'-bis(trimethoxysilylethyl tolylene) disulfide.

58. The process according to claim 4 where, for said organosilane polysulfide compound, at least 95 percent of n is 2; whcrc said R^2 radicals arc alkyl radicals selected from methyl, ethyl, n-propyl and n-decyl radicals; and where said R^1 radicals are selected from benzyl, alpha, alpha dimethylbenzyl, p-tolyl, p-nonylphenol and p-chlorophenol radicals.

59. The process according to claim 58 where organosilane disulfides of said organosilane polysulfide compounds are selected from at least one of:

3,3'-bis(trimethoxysilylpropyl) disulfide;

3,3'-bis(triethoxysilylpropyl) disulfide;

3,3'-bis(triethoxysilylethyl tolylene) disulfide; and

3,3'-bis(trimethoxysilylethyl tolylene) disulfide.

60. The process according to claim 4 wherein said organosilane disulfide of said organosilane polysulfide compound (iii) is sclcctcd from at least one of

3,3 '-bis(trimethoxysilylpropyl) disulfide;

3,3 '-bis(triethoxysilylpropyl) disulfide;

3,3'-bis(triethoxysilylethyl tolylene) disulfide; and

3,3'-bis(trimethoxysilylethyl tolylene) disulfide; where said carbon black has a CTAB value in a range of about 80 to about 150 and said silica, alumina and aluminosilicate have a BET surface area in a range of about 100 to about 300 square meters per gram, a dibutylphthalate (DBP) absorption value in a range of about 150 to about 350, a CTAB value in a range of about 100 to about 220 and a mercury porosimctry pore size distribution of: five percent less of its pores with a diameter of less than about 10 nm; 60 to 90 percent of its pores with a diameter of about 10 to about 100 nm; 10 to 30 percent of its pores with a diameter of about 100 to about 1000 nm and 5 to 20 percent of its pores with a diameter of greater than about 1000 nm.; wherein said sulfur donor additional additive is selected from at least one of dimorpholine disulfide, dimorpholine tetrasulfide, tetramethyl thiuram tetrasulfide, benzothiazyl-2,N dithiomorpholide, thioplasts, dipentamethylenethiuramhexasulfide and disulfidecaprolactame; wherein said vulcanization accclerator for sulfur vulcanizable elastomers additional additive is selected from at least one of mercaptobenzothiazole, tetramethyl thiuram disulfide, benzothiazole disulfidc, diphcnylguanidine, zinc dithiocarbamate, alkylphenoldisulfide, zinc butyl xanthate, N-dicyclohexyl-2-benzothiazolesulfenamide,

N-cyclohexyl-2-benzothiazolesulfenamide, N-oxydiethylenebenzothiazole-2-sulfenamidc, N,N diphenylthiourea, dithiocarbamylesulfenamide, N,N diisopropylbezothiozole-2-sulfenamide, zinc-2-mercaptotoluinfidazole, dithiobis (N mcthyl piperazine), dithiobis(N beta hydroxy ethyl piperazine) and dithiobis(dibenzyl amine); and wherein said organosilane polysulfide additional additive is selected from at least one of 3,3 '-bis(trimethoxysilylpropyl) trisulfide and tetrasulfide; 3,3'-bis(triethoxysilylpropyl) trisulfide and tetrasulfide; 3,3'-bis(triethoxysilylethyl tolylene) trisulfide and tetrasulfide; and 3,3'-bis(trimethoxysilylcthyl tolylene) trisulfide and tetrasulfide.

61. The process according to claim **4** which comprises the additional step of vulcanizing the prepared rubber composition at a temperaturc in a range of from about 140° C. to about 190° C.

62. A vulcanized rubber composition prepared according to the process of claim **61**.

63. The process according to claim **60** which comprises the additional steps of preparing an assembly of a tire of sulfur vulcanizable rubber with a tread comprised of the said rubber composition and vulcanizing the assembly at a temperature in a range of about 140° C. to about 190° C.

64. A vulcanized rubber tire prepared according to the process of claim **63**.

65. The process according to claim **60** wherein, for said organosilane compound, at least 95 percent of n is 2.

66. The process according to claim **65** which comprises the additional step of vulcanizing the prepared rubber composition at a temperature in a range of from about 140° C. to about 190° C.

67. A vulcanized rubber composition prepared according to the process of claim **66**.

68. The process according to claim **65** which comprises the additional steps of preparing an assembly of a tire of sulfur vulcanizable rubber with a tread comprised of the said rubber composition and vulcanizing the assembly at a temperature in a range of about 140° C. to about 190° C.

69. A vulcanized rubber tire prepared according to the process of claim **68**.

70. The process of claim 4 wherein said preparatory steps (A) are composed of at least two sequential mixing steps in which said elastomer, said particulate filler and said organosilane polysulfide compound are added to one or more of said sequential mixing steps and wherein said sulfur source and/or vulcanization accelcrator is/are added in a subsequent sequential preparatory mixing step.

71. The process of claim **4** wherein said preparatory steps (A) are composed of at least two sequential mixing steps in which about 20 to about 60 weight percent of the silica, the said organosilane disulfide compound and said sulfur source and/or vulcanization accelerator are added in one or more mixing steps and the remainder thereof added in at least one subsequent preparatory mix step.

72. The process of claim **1** wherein said organosilane polysulfide compound, in which at least 80 percent of n is 2, is added to said thermomechanical preparatory mixing in a form of a particulate comprised of about 25 to about 75 weight percent of said organosilane polysulfide compound and, correspondingly, about 75 to about 25 weight percent of particulate carbon black.

73. The process of claim **4** wherein said organosilane polysulfide compound, in which at least 80 percent of n is 2, is added to said thcrmomechanical preparatory mixing in a form of a particulate comprised of about 25 to about 75 weight percent of said organosilane polysulfide compound and, correspondingly, about 75 to about 25 weight percent of particulate carbon black.

74. The process of claim **60** whcrein said organosilane polysulfide compound, in which at least 80 percent of n is 2, is added to said thermomechanical preparatory mixing in a form of a particulate compriscd of about 25 to about 75 weight percent of said organosilane polysulfide compound and, correspondingly, about 75 to about 25 weight percent of particulate carbon black.

75. The process of claim **60** wherein said organosilane polysulfide compound, wherein at least 95 percent of n is 2, is added to said thermomechanical preparatory mixing in a form of a particulate comprised of about 25 to about 75 weight percent of said organosilane polysulfide compound and, correspondingly, about 75 to about 25 weight percent of particulate carbon black.

76. The process according to claim **60** which comprises the additional steps of preparing an assembly of a tire of sulfur vulcanizable rubber with a tread comprised of the said rubber composition and vulcanizing the assembly at a temperature in a range of about 140° C. to about 190° C.; and wherein the organosilane polysulfide compound, for which at least 80 percent of n is 2, is added to said thermomechanical preparatory mixing in a form of a particulate comprised of about 40 to about 60 weight percent of said organosilane polysulfide compound and, correspondingly, about 60 to about 40 weight percent of particulate carbon black.

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(72) 발명자	레네 제안 찌머 룩셈부르크 엘-1232 호발트 루에 어네스트 베레스 141 티에리 플로렌트 어드메 마테르네 벨기에왕국 베-6717 아테르트 루에 데 라 리베라티온 10 기오르기오 아고스티니 룩셈부르크 엘-7733 콜마-베르그 루에 데 룩셈부르그 7 프리드리히 비젤 룩셈부르크 엘-7378 보페르당게 루에 노페나이 90아 우베 에른스트 프랑크 룩셈부르크 엘-9080 에텔브룩크 아베누에 살렌티니 103
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(54) 실리카로 보강된 고무 조성물 및 그의 타이어에서의 용도

요약

본 발명은 고순도의 오가노실란 디설파이드를 사용함으로써 실리카 보강물을 함유하는 고무 조성물을 제조하기 위한 방법에 관한 것이다.

본 발명은 상기 방법에의해 제조된 트레드를 갖는 공기압 타이어를 제공한다.

명세서

[발명의 명칭]

실리카로 보강된 고무 조성물 및 그의 타이어에서의 용도

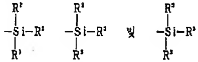
본 건은 요부공개 건이므로 전문 내용을 수록하지 않았음

(57) 청구의 범위

청구항 1

(A) (i) 공액된 디엔 단독중합체 및 공중합체, 및 하나 이상의 공액과 디엔과 방향족 비닐 화합물의 공중합체중에서 선택된 하나 이상의 가황성 탄선중합체 100중량부, (ii) 하나 이상의 칭전된 실리카, 알루미나, 알루미노실리케이트 및 카본 블랙으로 구성된 미립자 충진제(여기서, 충진제는 약 5 내지 약 85 중량%의 카본블랙을 함유한다.) 약 15 내지 약 100phr, (iii)일반식 $Z\text{-}R^1\text{-}S_n\text{-}R^1\text{-}Z$을 갖는 하나 이상의 오가노실란 폴리설파이드 화합물 약 0.05 내지 약 20중량부(상기 미립자 충진제 중량부당) 및 (iv) (a) (1) 황원소 및 (2) 황을 함유하고, 약 140℃ 내지 약 190℃의 온도에서 상기 황의 적어도 일부를 방출하는 특성을 갖는 폴리설피드성 유기 화합물로서의 하나 이상의 황 공여체중 하나 이상으로부터 선택된 유리 황원(단, 상기 황 원소 첨가 및 상기 황 공여체 첨가로 수득가능한 유리 황의 총량은 약 0.05 내지 약 2phr이다), 및 (b) 상기 황 공여체가 아닌 가황선 탄성중합체를 위한 하나 이상의 가황 촉진제 약 0.1 내지 약 0.5phr중에서 선택된 화합물로서의 하나 이상의 추가 첨가제를 하나 이상의 예비 혼합 단계에서 약 2 내지 약 20분의 총 혼합시간 동안 약 140℃ 내지 약 190℃의 온도로 열역학적으로 혼합시키며;(B) 이어서, 최종 열역학적 혼합 단계에서 약 1 내지 3분동안 약 100℃ 내지 약 130℃의 온도로 약 0.4 내지 약 3phr의 황원소(단, 이는 상기 예비 혼합 단계들에서 유도된 전체 원소 및/또는 유리 황이고, 상기 최종 혼합 단계에서 청가된 황 원자는 약 0.4 내지 약 5phr이다)및 하나 이상의 가황 촉진제를 블렌딩시키는 연속적인 단계

를 포함함을 특징으로 하는, 고무 조성물의 제조 방법:상기 일반식 $Z\text{-}R^1\text{-}S_n\text{-}R^1\text{-}Z$에서, n은 2 내지 8의 정수이나, 80%이상의 n이 2이고, Z는 하기 일반식으로 구성되는 그룹중에서 선택되고:



R^1은 총 탄소원자수 1 내지 18개의 치환되거나 또는 비치환된 알킬렌 그룹 및 총 탄소원자수 6 내지 12개의 치환되거나 또는 비치한된 아릴렌 그룹으로 구성된 그룹중에서 선택되고, R^2는 동일하거나 또는 상이할 수 있으며, 각각 탄소원자수 1 내지 4개의 알킬 그룹 및 페닐로 구성된 그룹중에서 선택되고, R^3는 동일하거나 또는 상이할 수 있으며, 각각 탄소원자수 1 내지 4개의 알킬 그룹, 페닐, 탄소원자수 1 내지 8개의 알콕시 그룹 및 탄소원자수 5 내지 8개의 사이클로알콕시 그룹으로 구성된 그룹중에서 선택된다.

청구항 2

제1항에 있어서, 상기 예비 혼합을 둘 이상의 열역학적 혼합 단계 사이에 고무 조성을을 약 50℃미만으로 냉각시키면서 약 140℃ 내지 약 190℃에서 상기 둘 이상의 혼합 단계에서 수행함을 특징으로 하는 방법.

청구항 3

제1항 또는 제2항에 있어서, 상기 가황성 탄성중합체의 경우, 상기 공액된 디엔을 이소프렌 및 1,3-부타디엔중에서 선택하고, 상기 비닐 방향족 화합물을 스티렌 및 알파 메틸 스티렌중에서 선택함을 특징으로 하는 방법.

청구항 4

제3항에 있어서, 상기 가황성 탄선중합체를 하나 이상의 천연 및 합성 시스 1,4-폴리이소프렌 고무, 에멀젼 중합 제조된 스티렌/부타디엔 공중합체 고무, 유기 용액 중합 제조된 스티렌/부타디엔 공중합체 고무, 3,4-폴리이소프렌 고무, 이소프렌/부타디엔 고무, 스티렌/이소프렌/부타디엔 삼원공중합체 고무, 시스 1,4-폴리 부타디엔 고우, 중간 비닐 폴리부타디엔 고무(35 내지 50중량% 비닐), 고항량 비닐폴리부타디엔 50 내지 75% 비닐) 및 에멀젼 중합 제조된 스티렌/부타디엔/아크릴로니트릴 삼원공중합체 공 및 부타디엔/아크릴로나트릴 공중합체 고무중에서 선택하는 방법.

청구항 5

제1항 내지 제4항중 어느 한 항에 있어서, 상기 실리카가 약 100 내지 약 300㎡/g의 BET표면적; 약 150내지 약 350의 디부틸프탈레이트(DBP) 흡수가; 약 100 내지 약 220의 CTAB가; 및 약 10nm미만의 직경을 갖는 공극 5% 미만, 약 10 내지 약 100nm의 직경을 갖는 공극 60 내지 9%, 약 100 내지 약 100nm의 직경을 갖는 공극 10 내지 30% 및 약 1000nm을 초과하는 직경을 갖는 공극 5 내지 20%의 수은 다공성측정 공극 크기 분포를 가짐을 특징으로 하는 방법.

청구항 6

제5항에 있어서, 상기 충진제가 약 15 내지 약 95중량%의 침전된 실리카, 및 이와 상응하게 약 5 내지 약 85중량%의 카본블랙으로 구성되고; 상기 카본블랙이 약 80 내지 약 150의 CTAB가를 가짐을 특징으로 하는 방법.

청구항 7

제1항 내지 제4항 중 어느 한 항에 있어서, 상기 충진제가 약 15 내지 약 100중량%의 알루미나 및 이와 상응하게 약 5 내지 약 85중량%의 가본블랙으로 구성되고; 상기 카본블랙이 약 80 내지 약 150의 CTAB가를 갖고, 상기 알루미나가 약 100 내지 약 220의 CTAB가, 및 약 10nm 미만의 직경을 갖는 공극 5% 미만, 약 10 내지 약 100nm의 직경을 갖는 공극 60 내지 90%, 약 100 내지 약 1000nm의 직경을 갖는 공극 10 내지 30% 및 약 1000nm을 초과하는 직경을 갖는 공극 5 내지 20%의 수은 다공성측정 공극 크기 분포를 가짐을 특징으로 하는 방법.

청구항 8

제1항 내지 제4항 중 어느 한 항에 있어서, 상기 충진제가 약 15 내지 약 100중량%의 알루미노실리케이트, 및 이와 상응하게 약 5 내지 약 85중량%의 카본블랙으로 구성되고; 상기 카본블랙이 약 80 내지 약 150의 CTAB가를 갖고, 상기 알루미노케이트가 약 100 내지 약 220의 CTAB가, 및 약 10nm 미만의 직경을 갖는 공극 5% 미만, 약 10 내지 약 100nm의 직경을 갖는 공극 60 내지 90%, 약 100 내지 약 1000nm의 직경을 갖는 공극 10 내지 30% 및 약 1000nm을 초과하는 직경을 갖는 공극 5 내지 20%의 수은 다공성측정 공극 크기 분포를 가짐을 특징으로 하는 방법.

청구항 9

제8항에 있어서, 상기 알루미노실리케이트를 (a) 무스코비트, 베릴, 디크로이트 세피올라이트 및 카올라나이트 중에서 선택된 알루미노실리케이트, 및 (b) (i) 실리케이트와 알루미네이트의 염기성 용액 또는 혼합울의 pH 조정에 의한 동시침전에의해, 또는 (ii) 이산화실리콘 및 $NaAlO_2$의 표면의 실란을 사이에서의 화학반응에 의해 제조된 합성 알루미노실리케이트중 하나 이상으로부터 선택항을 특징으로 하는 방법.

청구항 10

제9항에 있어서, 상기 동시침전된 합성 알루미노실리케이트에 있어서 약 5 내지 약 95%의 표면이 실리카잔가로 구성되고, 이와 상응하게 약 95 내지 약 5%의 표면이 알루미늄 잔기로 구성됨을 특징으로 하는 방법.

청구항 11

제10항에 있어서, 상기 합성 알루미노실리케이트가 M이 마그네슘 또는 칼슘인 일반식 $[(Al_2O_3)_x(SiO_2)_y(H_2O)_z]$; $[(Al_2O_3)_x(SiO_2)_yMO]$으로 표시됨을 특징으로 하는 방법.

청구항 12

제1항 내지 제11항 중 어느 한 항에 있어서, 총 약0.05 내지 약 5phr의 하나 이상의 알킬 실란(R′-Si-$(OR)_3$)을 상기 예비 열역학적 혼합 단계(들)에 첨가하며; 상기 식에서 R이 메틸, 에틸, 프로필 또는 이소프로필 라디칼이고, R`가 탄소원자수 1 내지 18개의 포화된 알킬 또는 탄소원자수 6 내지 12개의 아릴 또는 포화된 알킬 치환된 아릴 라디칼임을 특징으로 하는 방법.

청구항 13

제12항에 있어서, 상기 알킬 실란을 프로필트리에톡시 실란, 메틸트리에톡시 실란, 헥사데실트리에톡시 실란 및 옥타데실트리에톡시 실란중에서 하나 이상으로부터 선택됨을 특징으로 하는 방법.

청구항 14

제1항 내지 제13항 중 어느 한 항에 있어서, 상기 황 공여체가 추가 첨가제를 디모폴린 테트라설파이드, 테트라메틸 티우람 테트라설파이드, 벤조티아질-2, N 디티오모폴리드, 티오플라스트, 디펜타메틸렌티우람 헥사설파이드 및 디설파이드카프로락탐중 하나 이상으로부터 선택함을 특징으로 하는 방법.

청구항 15

제1항 내지 제14항 중 어느 한 항에 있어서, 상기 황 공여체 추가 첨가제를 3,3`-비스(트리메톡시실릴프로필)트리설파이드 및 테트라설파이드; 3,3`-비스(트리에톡시실릴프로필)트리설파이드 및 테트라설파이드; 3,3`-비스(트리에톡시실릴에틸 톨릴렌)트리설파이드 및 테트라설파이드; 및 3,3`-비스(트리메톡시실릴에틸 톨릴렌)트리설파이드 및 테트라설파이드 및 테트라설파이드 중 하나 이상으로부터 선택함을 특징으로 하는 방법.

청구항 16

제1항 내지 제 15항 중 어느 한 항에 있어서, 가황성 탄성중합체 추가 첨가제를 위한 상기 가황 촉진제를 머캡토벤조티아졸, 테트라메틸 티우람 디설파이드, 벤조티아졸디설파이드, 디페닐구아니딘, 아연 디티오카바메이트, 알킬페놀디설파이드, 아연 부틸 크산테이트, N-디사이클로헥실-2-벤조티아졸설펜아미드, N-사이클로헥실-2-벤조티아졸설펜아미드, N-옥시디에틸렌벤조티아졸-2-설펜아미드, N,N-디페닐티오우레아, 디티오카바밀레설펜아미드, N,N-디이소프로필벤조티오졸-2-설펜아미드, 아연-2-머캡토톨루이미다졸, 디티오비스(N-메틸피페라진) 디티오비스(N 베타 하이드록시 에틸 피페라진) 미 디티오비스(디벤질 아민) 중 하나 이상으로부터 선택함을 특징으로 하는 방법.

청구항 17

제1항 내지 제 16항 중 어느 한 항에 있어서, 상기 오가노실란 폴리설파이드 화합물에 있어서, 상기 R^2라디칼이 알킬 라디칼이고, 상기 R^1 라디칼이 알카릴, 페닐 및 할로알킬 라디칼중에서 선택됨을 특징으로 하는 방법.

청구항 18

제1항 내지 제 17항중 어느 한 항에 있어서, 상기 오가노실란 폴리설파이드 화합물에 있어서, 상기 알킬 라디칼이 메틸, 에틸 n-프로필 및 n-데실 라디칼중에서 선택되고; 상기 아르알킬 라디칼이 벤질 및 알파, 알파 디메틸벤질 라디칼중에서 선택되고; 상기 알카릴 라디칼이 p-톨릴 및 p-노닐페놀 라디칼중에서 선택되고; 상기 할로아릴 라디칼이 p-클로로페놀 라디칼임을 특징으로 하는 방법.

청구항 19

제1 내지 제18항 중 어느 한 항에 있어서, 상기 오가노실란 폴리설파이드 화합물중 오가노실란 디설파이드를 하기 그룹 중 하나 이상으로부터 선택함을 특징으로 하는 방법:3,3`-비스(트리메톡시실릴프로필)디설파이드; 3,3`-비스(트리에톡시실릴프로필)디설파이드;3,3`-비스(트리에톡시실릴에틸 톨릴렌)디설파이드 및 3,3`-비스(트리메톡시실릴에틸 톨릴렌)디설파이드.

청구항 20

제1항 내지 제19항 중 어느 한 항에 있어서, 상기 오가노실란 폴리설파이드에 있어서, 95%이상의 n이 2이고; 상기 R^2라디칼이 메틸, 에틸,n-플로필 및 n-데실 라디칼중에서 선택된 알킬 라디칼이고; 상기 R^1라디칼이 벤질, 알파, 알파 디메틸벤질, p-톨릴, p-노닐페놀 및 p-클롤페놀 라디칼임을 특징으로 하는 방법.

청구항 21

제1항 내지 제20항중 어느 한 항에 있어서, 상기 오가노실란 폴리설파이드 화합물이 하기 화합물중 하다 이상으로부터 선택된 오가노실란 디설파이드임을 특징으로 하는 방법: 2,2`-비스(트리메톡시실릴에틸)디설파이드; 3,3`-비스(트리메톡시실릴프로필)디설파이드;3,3`-비스(트리에톡시실릴프로필)디설파이드; 2,2`-

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비스(트리-3급-부톡시실릴에틸)디설파이드:3,3`-비스(트리-t-부톡시에틸)디설파이드:3,3`-비스(트리에톡시실릴에틸 톨릴렌)디설파이드: 3,3`-비스(트리메톡시실릴에틸 톨릴렌)디설파이드;3,3`-비스(트리이소프로폭시프로필)디설파이드; 3,3`-비스(트리옥톡시프로필)디설파이드;2,2`-비스(2`-에틸헥속시실릴에틸)디설파이드; 2,2`-비스()디설파이드;2,2`-비스(디메톡시 메톡시실릴에틸)디설파이드;3,3`-비스(메톡시에톡시프로폭시실릴프로필)디설파이드;3,3`-비스(메톡시 디메틸실릴프로필)디설파이드:2,2`-비스(사이클로헥속시 디메틸실릴프로필)디설파이드: 4,4`-비스(트리메톡시실릴부틸)디설파이드: 3,3`-비스(트리메톡시실릴-3-메틸프로필)디설파이드; 4,4`-비스(트리메톡시실릴부틸)디설파이드: 3,3`-비스(트리메톡시시릴-3-메틸프로필)디설파이드:4,4`-비스(트리메톡시실릴부틸)디설파이드:3,3`-비스(트리메톡시실릴-3-메틸프로필)디설파이드: 3.3`-비스(트리프로폭시실릴-3-메틸프로필)디설파이드:3.3`-비스(디메톡시메틸실릴-3-에틸프로필)디설파이드:3.3`-비스(트리메톡시실릴-2-메틸프로필)디설파이드: 3.3`-비스(디메톡시페닐실릴-2-메틸프로필)디설파이드:3.3`-비스(트리메톡시실릴사이클로헥실)디설파이드:12,12`-비스(트리메톡시실릴도데실)디설파이드: 12,12-비스(트리에톡시실릴도데실)디설파이드: 18,18`-비스(트리메톡시실릴옥타데실)디설파이드: 18,18`-비스(메톡시디메실릴옥타데실)디설파이드: 2,2`-비스(트리메톡시실릴-2-메틸에틸)디설파이드: 2,2-비스(트리에톡시실릴-2-메틸에틸)디설파이드: 2,2`-비스(트리프로폭시실릴-2-메틸에틸)디설파이드:및 2,2`-비스(트리옥톡시실릴-2-메틸에틸)디설파이드.

청구항 22

제1항 내지 제15항 중 어느 한 항에 있어서. 상기 오가노실란 폴리설파이드 화합물을 3,3`-비스(트리메톡시실릴프로필)디설파이드. 3,3`-비스(트리에톡시설릴프로필)디설파이드. 3,3`-비스(트리에톡시실릴에틸 톨릴렌)디설파이드.및 3.3`-비스(트리메톡시실릴에틸 톨릴렌)디설파이드중 하나 이상으로부터 선택하고: 상기 카보블랙이 약 80 내지 약 150의 CTAB가를 갖고: 상기 실리카. 알루미나 및 알루미노실리케이트가 약 100 내지 약 300m^2/g의 BET표면적. 약 150 내지 약 350의 디부틸프탈레이트(DBP) 흡수가. 약 100 내지 약 220의 CTAB가. 및 약 100nm 미만의 직경을 갖는 공극 5%미만. 약 10 내지 약 100nm의 직경을 갖는 공극 60 내지 90%. 약 100 내지 약 1000nm의 직경을 갖는 공극 10 내지 30% 및 약 1000nm을 초과하는 직경을 갖는 공극 5 내지 20%의 수은 다공성측정 공극 크기 분포를 갖고; 상기 황 공여제 추가 첨가제를 디모폴린 디설파이드. 디모폴린 테트ㅏ서파이드. 테트라메틸. 티우랑 테트라설파이드. 벤조티아지-2.N 디티오모폴리드. 티오플라스트. 디펜타메틸렌티우람헥사서파이드 및 디설파이드카프로락탐중 하나 이상으로부터 선택하고; 가황성 탄성중합체 추가 청가제를 위한 상기 가황 촉진제를 머캡토벤조티아졸. 테트라메틸 티우람 디서파이드. 벤조티아조 디설파이드. 디페니구아니딘. 아연 디티오카바메이트. 알킬페노 디설파이드. 아연 부틸 크산테이트. N-디사이클로헥실-2-벤조티아졸설펜아미드. N-사이클로헥실-2-벤조티아졸설펜아미드. N-옥시디에틸렌벤조티아졸-2-설펜아미드. N.N-디페닐티오우레아. 디티오카바밀레설펜아미드. N.N-디이소프로필벤조티오졸-2-설펜아미드. 아연-2-머캡토톨루이미다졸. 디티오비스(N-메틸피페라진). 디티오박스(N 베타 하이드록시 에틸 피페라진) 및 디티오비스(디벤질 아민)중 하나 이상으로부터 선택하고; 상기 오가노실란 폴리설파이드 추가 첨가제를 3,3`-비스(트리메톡시실릴에틸 톨릴렌)트리설파이드 및 테트라설파이드중 하나 이상으로부터 선택항을 특징으로 하는 방법.

청구항 23

제1항 내지 제22항 중 어느 한 항메 있어서. 제조된 고무 조성물을 약 140℃ 내지 약 190℃의 온도에서 가황시키는 추가의 단계를 포함함을 특징으로 하는 방법.

청구항 24

제23항의 방법에 따라 제조함을 특징으로 하는 가황된 고무 조성물.

청구항 25

제20항에 있어서. 가황성 고우 타이어와 상기 고우로 구성된 트레드의 어셈블리를 제조하고. 상기 어셈블리를 약 140℃ 내지 약 190℃의 온도에서 가황시키는 추가의 단계를 포함함을 특징으로 하는 방법.

청구항 26

제25항의 방법에 따라 제조함을 특징으로 하는 타이어.

※ 참고사항 : 최초출원 내용에 의하여 공개하는 것임.

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